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ENVIRONMENTAL ASSESSMENT BOARD



ONTARIO HYDRO DEMAND/SUPPLY PLAN HEARINGS

VOLUME: 142

DATE: Tuesday, May 5, 1992


BEFORE:

HON. MR. JUSTICE E. SAUNDERS	Chairman
DR. G. CONNELL	Member
MS. G. PATTERSON	Member

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ENVIRONMENTAL ASSESSMENT BOARD
ONTARIO HYDRO DEMAND/SUPPLY PLAN HEARING

IN THE MATTER OF the Environmental Assessment Act,
R.S.O. 1980, c. 140, as amended, and Regulations
thereunder;

AND IN THE MATTER OF an undertaking by Ontario Hydro
consisting of a program in respect of activities
associated with meeting future electricity
requirements in Ontario.

Held on the 5th Floor, 2200
Yonge Street, Toronto, Ontario,
Tuesday, the 5th day of May,
1992, commencing at 10:00 a.m.

VOLUME 142

B E F O R E :

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MS. G. PATTERSON	Member

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1 ---Upon commencing at 10:03 a.m.

2 THE REGISTRAR: Please come to order.

3 This hearing is now in session. Be seated, please.

4 THE CHAIRMAN: Ms. Spoel.

5 MS. SPOEL: Thank you, Mr. Chairman.

6 DAVID WHILLANS,
7 KURT JOHANSEN,
8 FRANK CALVIN KING,
 WILLIAM JOHN PENN,
 IAN NICHOL DALY; Resumed.

9 CROSS-EXAMINATION BY MS. SPOEL:

10 Q. I would like to start off, if I
11 might, by asking some questions about tritium, not as
12 an emission from facilities but at the very end of the
13 process.

14 I would like to start by asking the
15 panel, and I'm not sure to whom this question should be
16 addressed, so perhaps you can decide amongst yourselves
17 who the most appropriate is to answer it.

18 There is a statement on page 1 of a
19 document called Radioactive Materials Management at
20 Ontario Hydro, An Overview, and that's been marked as
21 part of Interrogatory 9.9.41. It's already been
22 referred to, it's marked as 520.19.

23 I am simply going to cite a statement
24 from it, I don't think there's any need to actually
25 refer to it and the statement, it is right on the first

1 page under introduction:

2 Ontario Hydro is committed to the
3 responsible and comprehensive management
4 of all radioactive materials resulting
5 from the operation of its nuclear power
6 stations.

7 Now, I take it that that statement --
8 this document is dated May, 1991. I take it that that
9 statement continues to be the policy of Ontario Hydro?

10 MR. PENN: A. That's correct.

11 Q. Now, I understand that tritium is
12 created as a contaminant during the operation of the
13 nuclear power plants by Ontario Hydro?

14 A. Well, it's a by-product of neutron
15 interaction with heavy water.

16 Q. And I understand that Ontario Hydro
17 operates a tritium removal facility whereby it removes
18 this by-product or contaminant from the heavy water?

19 A. Yes.

20 Q. And the reason for that is to reduce
21 occupational exposure and emissions to the environment?

22 A. That was the reason, yes.

23 Q. Now, I also understand that the
24 tritium that is removed at the tritium removal facility
25 is sold by Ontario Hydro to customers?

1 A. As far as I know, Ms. Spoel - maybe
2 one of my colleagues can help here - we have sold a few
3 hundred grams for the purposes of navigational lights
4 or self-powered lighting.

5 MR. KING: A. If I could add something
6 there. There is a policy in place that's been reviewed
7 by various levels of government where we are allowed to
8 make sales to, as Mr. Penn has mentioned, the
9 self-powered lighting manufacturing facilities in
10 Canada, to approved Canadian and international fusion
11 projects, as well as to approved international
12 radiopharmaceutical companies.

13 And these policies have been reviewed by
14 the Ontario government and the federal government and
15 require various -- if it's outside the country, require
16 export permits, and there is limitations on to the
17 countries and companies that internationally that this
18 tritium can be sold to.

19 Q. Thank you. I will perhaps come back
20 to some of that in a moment. In fact, if I can get
21 back to where I was, there is some tritium being sold
22 by Ontario Hydro at present?

23 MR. PENN: A. As far as I know, just for
24 self-powered lighting to date. Now, I believe there
25 has been discussions with regard to small quantities

1 for fusion research.

2 MR. KING: A. If I could add to that. I
3 believe last year we had sold 70 grams to the lighting
4 industry. I believe this year sales or deliveries to
5 some international fusion projects will begin.

6 Q. Whether it's 70 grams or regardless
7 of what the purpose of the sale or the purpose of the
8 use of it is, what does Ontario Hydro consider its
9 responsibility to be for the management of the tritium
10 once it has been sold?

11 A. Well, as I mentioned, that there have
12 been established certain rules that we are allowed to
13 sell tritium under, and I am not familiar myself with
14 the details of those rules or the details of the
15 contracts with the specific companies. I am not sure
16 if anybody else knows, but I am not familiar with those
17 details.

18 Q. Well, can I take it then that once
19 it's been sold, assuming that the rules have been
20 followed and so on - and we have no suggestion that
21 they are not being - once it has been sold by Ontario
22 Hydro, would it be fair to say that Ontario Hydro takes
23 no further responsibility for the final use or disposal
24 of that tritium?

25 A. I don't know. Those responsibilities

1 would be in the agreements and contracts, I would
2 assume, I have never seen one of these contracts.

3 And as I have just said, I am afraid I am
4 not familiar with those, and I am not sure if some
5 other people on the panel want to say something on
6 that.

7 DR. WHILLANS: A. Perhaps I could
8 comment. I don't know the details either, but I would
9 be surprised if there weren't conditions that would
10 limit the use.

11 The reason I say that is I am familiar
12 with a tritium safety course which Hydro has
13 participated in, and we now require people attending
14 the course to sign an agreement that they are not going
15 to be involved in weapons proliferation. I would be
16 surprised if we didn't have some similar kind of
17 condition on our other operations with respect to
18 tritium.

19 Q. Perhaps I can ask this a slightly
20 different way. Does Ontario Hydro -- I understand the
21 way it works, or I believe I understand the way it
22 works, is you sell some tritium to the self-powered
23 lighting industry for the manufacture of self-powered
24 lights, have I got it right so far?

25 MR. PENN: A. Yes, we have.

1 Q. Thank you. Those lights are
2 presumably sold by their manufacturers to various users
3 who need self-powered lights?

4 A. Yes, they are for remote areas for,
5 shall we say, landing lights in far Northern Ontario
6 and Northern Canada.

7 [10:10 a.m.]

8 And I understand that they will have
9 application in marker buoys in channels, but I don't
10 know whether these lights have presently been installed
11 for that purpose, but that's one of the purposes that
12 the tritium could be used for.

13 And of course, for exit signs in
14 buildings or theatres, where you want to make sure, in
15 an emergency if the electricity power goes off, that
16 people know where the exits are.

17 Q. Right. I have no quarrel with the
18 purposes of these particular uses.

19 My question is: Does Ontario Hydro have
20 any control or responsibility for, let's use example,
21 exit signs, where the exit signs are installed,
22 assuming these are manufactured into exit signs?

23 A. Well, I don't really know. I doubt
24 it personally.

25 MR. KING: A. I am aware that the

1 contracts, where we sell tritium to a lighting
2 manufacturer or to anybody, that these contracts, I am
3 advised, have additional clauses in them that govern
4 the end-use of the tritium and these clauses control
5 the transfer or resale of the material to third
6 parties.

7 Q. Does Ontario Hydro monitor whether
8 that's being carried out the way it is supposed to be?

9 A. I am afraid I am not aware of that.

10 I know that the Atomic Energy Control
11 Board and other federal bodies are very concerned about
12 these sort of matters, and I assume that they have put
13 in place the appropriate policies.

14 MR. JOHANSEN: A. Ms. Spoel, I wonder if
15 I could just add that in response to one of your
16 interrogatories, namely 9.46.6, there was a three-line
17 answer, it's very brief so perhaps I could simply read
18 it into the record. It addresses your question now to
19 some extent.

20 Q. Please do.

21 A. The answer is:

22 Ontario Hydro has not exported any
23 tritium outside of Canada.

24 And this was as of November of 1991, the
25 date of this answer.

1 It goes on to say:

2 If any exports are made in the future,
3 Ontario Hydro will keep track of their
4 end-uses.

5 And finally it says:

6 Exports of Ontario Hydro tritium will
7 be limited to the end-uses of
8 international fusion research and
9 radiopharmaceutical research.

10 As Messrs. Penn and King have already
11 indicated.

12 So it's that middle sentence, I guess,
13 that gets close to addressing your present question.
14 And that's really all I can add to it.

15 THE CHAIRMAN: We should have a number
16 for 9.46.6.

17 THE REGISTRAR: .142, Mr. Chairman.

18 ---EXHIBIT NO. 520.142: Interrogatory No. 9.46.6.

19 MS. SPOEL: Q. Well, without getting
20 into precisely what the uses are, and as I indicated
21 earlier I am not disputing, I have no evidence to the
22 contrary that would in any way contradict the answer to
23 that interrogatory, and I am not trying to suggest that
24 Ontario Hydro is selling anything that it shouldn't, or
25 that it isn't following the rules.

1 What I am trying to establish is, what
2 are the rules or what, in practice, happens once it has
3 been sold, assuming of course that it has been sold to,
4 for example, the self-powered lighting industry. Once
5 the material has been manufactured into a light,
6 whether it's a runway light, a marker buoy or an exit
7 light for a building, my question was whether Ontario
8 Hydro as any control over who the actual users of those
9 lights are. Mr. King's answer was there was some
10 material in the contract that indicates that it is only
11 to be sold for those purposes.

12 Is that fair, as a summary?

13 MR. KING: A. The material can't be
14 resold --

15 Q. Resold for another use.

16 A. Now, what I don't know is whether
17 that means can't be resold as kind of bulk tritium, if
18 you will. I assume they can sell the light that they
19 have produced, just as people can sell watches where
20 watches with tritium are sold as well.

21 Q. Dealing with the situation where the
22 light is sold as produced, sold for its intended
23 purpose, as a light, what happens to that light once it
24 is no longer useful as a light?

25 A. I am afraid I can't help you there at

1 all.

2 Q. So I take it that Ontario Hydro does
3 not take back used lights that still may have half the
4 tritium in them, when they are no longer useful as
5 lights?

6 A. All I can say is that I am just not
7 aware of what happens at all, unless somebody else can
8 help me on the panel.

9 DR. WHILLANS: A. As Mr. King has said,
10 we have only been involved in these sales for a year.
11 So essentially the lights that are out now are not our
12 tritium, I don't have we have set up anything yet to
13 recycle.

14 Q. Now, I am not personally involved
15 obviously in the manufacture of these lights, but I
16 assume that there is a point at which the tritium will
17 decay to an extent that the light is no longer useful,
18 but there will be still be some tritium left in them;
19 is that a reasonable assumption?

20 A. To my knowledge, any material like
21 this will only be sold for consumer use if the levels
22 are so low that they are not hazardous, if uncontrolled
23 disposal is made. So that this applies to smoke
24 detectors and all sorts of things that contain
25 radioactivity.

1 If there were higher levels, then this
2 would be some kind of a use licenced by the AECB and
3 they would look at how it was going to be disposed of.

4 So I guess I am saying I would have
5 thought that these lights were probably of sufficiently
6 low tritium content that they would not be hazardous.
7 We are talking about the ones that are used in
8 theatres, for example.

9 Q. I take it then that Ontario Hydro
10 does not concern itself corporately with the disposal
11 of these used products or the qualifications of the
12 people who install them or what happens to them if they
13 break, or anything of that nature; is that fair?

14 MR. B. CAMPBELL: Mr. Chairman, I think
15 that's clearly not fair in terms of what the witnesses
16 have said. They are just not sufficiently familiar
17 with the details of how all of these matter may or may
18 not be addressed to be able to respond to a question
19 like that. I think they have said what they can in the
20 area.

21 THE CHAIRMAN: Perhaps we should the
22 information: (A) What are the terms of the contract,
23 and (B), what if any follow up is conducted by Ontario
24 Hydro? Perhaps you should have both those pieces of
25 information.

1 MR. B. CAMPBELL: If we could get an
2 undertaking for that, we will.

3 THE REGISTRAR: 532.16.

4 THE CHAIRMAN: Does that cover your
5 concerns?

6 MS. SPOEL: Yes, it does. Thank you very
7 much, Mr. Chairman.

8 ---UNDERTAKING NO. 532.16: Ontario Hydro undertakes to
9 provide: (A) what are the terms of the
10 tritium contract, and (B), what if any
follow up is conducted by Ontario Hydro?

11 MS. SPOEL: Q. If I might move on to
12 another area. I understand that approximately in 1989
13 the Ontario government did decide to allow Ontario
14 Hydro to sell tritium on the world market.

15 Now, Mr. Johansen's helpful reference to
16 the interrogatory answer indicates that none has been
17 sold for export to date. Does that continue to be the
18 case?

19 MR. KING: A. I believe I indicated a
20 few minutes ago that we expect to deliver tritium to an
21 international fusion project back in St. Karlsruhe,
22 Germany, later on this year.

23 To my knowledge, as of a few weeks ago
24 when I checked, no deliveries have been made to date,
25 but I believe they are contracted for.

1 Q. I take it that whether or not the
2 tritium is used as it is supposed to be, after sold by
3 Ontario Hydro, is something that is also essentially
4 outside the control of Ontario Hydro once it's left
5 this country?

6 A. Well, I believe there will be clauses
7 in the contract to prevent that sort of thing.

8 Now, if you are saying whether Ontario
9 Hydro is over there acting as a policeman to make sure
10 something doesn't happen, I would expect that is not
11 the case, but again I say I have no knowledge of this
12 level of detail.

13 [10:23 a.m.]

14 THE CHAIRMAN: Well, that would be
15 encompassed in the undertaking, I think.

16 MS. SPOEL: Yes.

17 Q. I was going to ask if we could have
18 the same information with respect to those protections
19 as well.

20 MR. JOHANSEN: A. Ms. Spoel, perhaps one
21 additional comment might be helpful.

22 In the overview document which you
23 referred to earlier, Exhibit 520.19, in the section 2
24 which deals with goal and principles for purposes of
25 managing radioactive materials, there is one item which

1 indicates that Ontario Hydro will deal only with
2 licensed materials suppliers, contractors and
3 customers, and the footnote that goes with the
4 customers' part indicates that this is intended to mean
5 customers to whom we sell radioisotopes whether it be
6 Cobalt-60 or tritium.

7 So there is a regulatory system that
8 governs the use by these customers of radioisotopes
9 that they purchase from Ontario Hydro.

10 Q. Thank you, Mr. Johansen. I presume
11 that that applies to the regulatory system referred to
12 in that document. But that document, as I understand
13 it, only refers to domestic sales, at least the only
14 customers mentioned in it are domestic customers, and I
15 assume the regulatory system is that set up by the
16 Atomic Energy Control Board. That does not apply, I
17 believe, in Germany and I think the undertaking should
18 answer what the controls are on its use there.

19 MR. KING: A. I have a little more
20 pertinent information, I believe. The export policy
21 requires that tritium only be sold to countries which
22 have signed the nuclear non-proliferation treaty or
23 have undertaken equivalent non-proliferation
24 obligations, that these countries also have submitted
25 to the International Atomic Energy Agency Monitoring

1 Program and, as well, have accepted any other Canadian
2 government or contractual requirements.

3 Q. I would like to address another area
4 completely which is the matter of research in nuclear
5 energy, and for this purpose I would like to refer
6 briefly to another interrogatory answer which is No.
7 9.14.55.

8 THE REGISTRAR: That's .143.

9 ---EXHIBIT NO. 520.143: Interrogatory No. 9.14.55.

10 MS. SPOEL: Q. Now, this document would
11 appear to indicate that in 1990, slightly over \$100
12 million was spent by Ontario Hydro on nuclear research
13 and development costs; is that correct?

14 MR. PENN: A. Yes. The interrogatory
15 answer says 102.3 million. That actually, as the entry
16 shows, is partly the CANDU owners group and partly
17 research done either in Hydro or elsewhere separate
18 from the CANDU owners group.

19 Q. And how much is CANDU owners group
20 and how much is the other category? Do you have that
21 information?

22 A. Well, I can't give it to you for
23 1990, but the CANDU owners group budget in 1991
24 totalled \$81.9 million. That was Ontario Hydro's share
25 to the CANDU owners group fund.

1 Q. I'm sorry, 80...?

2 A. 81,932,000.

3 THE CHAIRMAN: Do you have the equivalent
4 figure for 1991 for the 102.3?

5 MR. PENN: No, I don't, sir, but I
6 believe that it is a very similar figure. I would have
7 to check the exact amount. I don't have it with me.

8 THE CHAIRMAN: So 80 per cent roughly
9 goes to the owners group; is that right?

10 MR. PENN: Yes.

11 THE CHAIRMAN: All right. And has that
12 been consistent throughout the years? Has that been
13 consistent throughout the years, or do you know?

14 MR. PENN: I don't really know. The
15 funding of the CANDU owners group has increased
16 significantly in recent times because of the
17 contributions to used fuel management research.

18 MS. SPOEL: Q. That \$100 million figure
19 in 1990 appears to be an increase from \$40 million some
20 five years earlier in 1986; is that correct as well?

21 MR. PENN: A. Yes.

22 Q. So, in effect, there was a 150 per
23 cent increase in expenditures on research and
24 development by Ontario Hydro in that five-year period?

25 A. Yes. It's mainly due to

1 significantly increased funding of the used fuel
2 management research and development program and other
3 major programs such as pressure tube research and
4 nuclear safety research.

5 Q. Now, you indicated to the Chairman
6 that you do not have the figure for 1991 that would
7 correspond to that \$102 million; is that...

8 A. If you would just give me a moment
9 I'll look through what I have got here. I don't think
10 I do, from reviewing this last night.

11 No, I don't have that number. I have
12 extensive detail on the CANDU owners group which is the
13 bulk of it.

14 Q. Then do you have a budget figure for
15 1992 for either the CANDU owners group or the overall
16 Ontario Hydro spending?

17 A. Not with me, no.

18 Q. Can you provide that to us, please?

19 MR. B. CAMPBELL: If it's available.

20 MR. PENN: It's available.

21 MR. B. CAMPBELL: I don't know if it's
22 readily available. If we take an undertaking --
23 perhaps if we wanted to wait until after break we could
24 find out whether we need to take an undertaking or
25 whether it can be done quickly.

1 THE CHAIRMAN: All right.

2 MR. PENN: It's certainly of the same
3 order as I testified earlier, Ms. Spoel. It will be in
4 the order of -- it probably is the same sort of number
5 with inflation added, it is of that order.

6 MS. SPOEL: Unless it turns out to be
7 different substantially from that, that is probably
8 sufficient for our purposes.

9 MR. PENN: We can check it at the break,
10 yes.

11 MR. B. CAMPBELL: That's fine.

12 MS. SPOEL: Q. Mr. Penn, you have
13 indicated that this figure includes the CANDU owners
14 share of the budget and also internal and external
15 research done by Ontario Hydro.

16 How do you define what gets included in
17 very general terms in the research and development
18 spending as opposed to other categories?

19 MR. PENN: A. Well, at this point in
20 time -- you are talking about nuclear; are you in the
21 question?

22 Q. Yes, nuclear specifically.

23 A. At this time the research and
24 development work is totally associated with the
25 operation of our current nuclear generating stations.

1 At one time we did have a small fraction
2 of the money aimed at developing future nuclear plant,
3 specific details of future nuclear plant, but we are
4 not funding that at the moment.

5 Q. Is that because of the current
6 government moratorium on construction of new nuclear
7 facilities?

8 A. I don't think the government asked us
9 to cease that, Hydro though took the decision in 1990.

10 Q. Now, the CANDU owners group, I
11 presume, has a larger budget than simply the
12 contribution made by Ontario Hydro of some \$82 million
13 in 1990?

14 A. Yes, it does. The CANDU owners group
15 has membership of Atomic Energy of Canada Research
16 Company and the other utilities in Canada that own
17 CANDUs, Hydro Quebec and New Brunswick Power
18 Commission. And I believe this year some money is
19 being provided by the Korea electric utility that owns
20 CANDUs.

21 The whole purpose of the CANDU owners
22 group is to do research that is necessary to ensure the
23 safety and reliable performance of CANDU plants.

24 Q. What's the overall research project
25 then for the CANDU owners group?

1 A. Well, I can give it to you for 1991.

2 Q. That will be great.

3 A. The total expenses in 1991 were 174
4 million -- 173,242,000.

5 Q. And that is entirely -- that is all
6 attributable to research and development activities?

7 A. Yes, it is.

8 Q. Now, in addition to the CANDU owners
9 group, I understand that Ontario Hydro funds other
10 external research whether through universities or other
11 agencies; is that correct?

12 A. We do some research in our own
13 research division, part of which is paid for out of the
14 CANDU owners group and part of it is funded directly by
15 the company, and we also fund some universities to do
16 research and other private laboratories.

17 My colleague has just reminded me that
18 when you asked the question about whether all the 173
19 million was devoted to research, of course, some of it
20 is devoted to administration of the program and for the
21 expense of running the NRU reactor at Chalk River,
22 which is a considerable amount of money.

23 Q. So of the 173 million, 80 per cent of
24 that is spent on research, something of that order?

25 A. Well, the NRU research reactor, which

1 of course is used for nuclear safety experiments and
2 for looking at fuel under certain circumstances and for
3 thermal hydraulic experiments, I suppose you can say
4 that's part of the research, but the cost of running
5 that research reactor is of the order of \$22 million a
6 year.

7 Q. Thank you. Now, some of the external
8 work that you referred to within universities and
9 laboratories, I take it that some of that work is also
10 funded by other agencies whether government or other
11 groups through matching grants and the like?

12 A. Well, that's certainly a process that
13 I am familiar with, but whether this particular
14 research is, I don't know.

15 I don't know the details of matching
16 grants with all the university research work. I am
17 only familiar with that in the Risk Institute of which
18 I am a director at the University of Waterloo. That I
19 do know, but that's not nuclear research.

20 Q. How are the particular problems, on
21 which research work is done, selected, whether it's
22 within the CANDU owners group or directly by Ontario
23 Hydro?

24 A. Well, we have a directing committee
25 of the CANDU owners group whose membership involves

1 senior staff of each utility and AECL and the chairman
2 of this committee is actually my boss, so it's chaired
3 by Ontario Hydro, and there is a series of working
4 parties associated with each of the disciplines
5 involved who submit proposals for research related to
6 the issues that are before us today, and then the
7 directing committee determines the priorities and where
8 the emphasis should be.

9 Q. What are the current issues that are
10 of highest priority at the moment?

11 A. Well, the easiest way to answer this,
12 I think, is that the program is split into five main
13 categories and within each of those categories there is
14 a series of different research topics.

15 [10:40 a.m.]

16 So the main categories are No. 1, safety
17 experiments and licensing-related experiments. So we
18 have the safety and licensing R&D program.

19 No. 2, is the fuel channel R&D program.
20 And we are talking about programs related to normal
21 operating conditions in a reactor and accident
22 conditions.

23 No. 3, is called CANDU technology
24 program, and this has to do with process systems and
25 equipment, fuel handling, chemical engineering and

1 processes in, for example, steam generators or
2 condensers.

3 And No. 4, which is a large program is
4 the waste management program.

5 And the fifth one is the health and
6 safety program, related to health effects of ionizing
7 radiation.

8 Then of course there is the CANDU Owner's
9 Group, R&D administration, including the cost of
10 operating the NRU research.

11 So those are the main topics. And within
12 one each of them there are up to, in some cases, 10 or
13 more programs.

14 They are all aimed at research to review
15 current issues or to do further study of safety-related
16 aspects.

17 Q. And what do you anticipate are the
18 types of problems that that group is going to be
19 dealing with during the time frame of the DSP over the
20 next 25 years?

21 A. Well, I would imagine that there
22 would be a shifting emphasis. There will always be
23 programs related to understanding the best way of
24 solving problems associated with conventional equipment
25 in our power stations.

1 For example, if we had a leak in a seal
2 somewhere and the deterioration of the seal was due to
3 the corrosive circumstances or irradiation or fretting
4 or whatever, then we would do research to determine
5 what nature of seal would solve the problem. So it's
6 that sort of thing.

7 I would expect there would be a
8 continuing level of activity in nuclear safety.

9 I don't think it would increase from its
10 present level; it may in fact reduce. But I anticipate
11 that a nuclear safety program will continue to be
12 always vigilant on these issues.

13 Once the concept technology for waste
14 management disposal has been heard before EARP and the
15 FEARO process, that's the Environmental Review and
16 Approval Process, the funds associated with that
17 program will reduce substantially because we will start
18 to enter the capitalized funding phase of it, and that
19 money then wouldn't come from OM&A, which is what we
20 are talking about.

21 So I would tend to think that apart from
22 inflation, that the budget in this area will reduce
23 with time. And if my colleagues can have any more
24 opinion on that matter...

25 MR. DALY: A. I think a couple of issues

1 I do see as important over the next few years would be
2 steam generator-related issues, we have talked about
3 steam generator concerns. I would see that being a
4 focus there. And as at the plants age I would see some
5 more focus on plant life assurance and plant life
6 extension, aging type of issues which COG has taken
7 some interest at the moment, and I think that would
8 naturally be a development as the plants get.

9 MS. SPOEL: Thank you. Those are all the
10 questions I have.

11 THE CHAIRMAN: Thank you, Ms. Spoel.

12 Where is Mr. Campbell?

13 MR. M. CAMPBELL: Excuse me, I just had
14 last minute instructions.

15 It's a bit early for the morning break,
16 but I expect it will take me five minutes to set up.

17 THE CHAIRMAN: Just go ahead, take your
18 time. We are relaxed.

19 ---Off the record discussion.

20 MR. M. CAMPBELL: It seems, Mr. Chairman,
21 that every lawyer who has preceded me forget to ask a
22 question and has asked me to fill in, so I have a
23 number of matters dumped upon me.

24 I think perhaps the first order of
25 business might be to, Mr. Chairman, might be to file a

1 bundle of exhibits, and perhaps if we take a moment or
2 so we can just go through them. I have had a chat with
3 Mr. Lucas about getting them into some sort of order.

4 I have also reviewed the exhibits the
5 other evening with Dr. Whillans, so I think we should
6 be fairly prompt in going through them.

7 The first document is an extract from
8 UNSCEAR, here is the original. I gather it has been
9 produced. I intend to refer to a couple of pages from
10 that and I have highlighted those for Dr. Whillans'
11 purposes. That I thought might be easier to handle
12 than this volume.

13 I don't know if Mr. Lucas has numbers.

14 THE REGISTRAR: Exhibit No. 653, Mr.
15 Chairman.

16 THE CHAIRMAN: Thank you.

17 ---EXHIBIT NO. 653: Extracts from UNSCEAR.

18 MR. M. CAMPBELL: The second is an
19 interrogatory, extract from Interrogatory 9.22.54 which
20 a list of radionuclides. I gather a question was put
21 on what radionuclides we were speaking about.

22 That's correct, a letter plus a list of
23 extracts, a list of radionuclides.

24 THE REGISTRAR: 654.

25 THE CHAIRMAN: Thank you.

1 ---EXHIBIT NO. 654: Extract from Interrogatory
2 9.22.54; a list of radionuclides.

3 DR. WHILLANS: Excuse me, Mr. Campbell,
4 were you just given a number for the UNSCEAR 1988
5 document?

6 MR. M. CAMPBELL: Just my extract.

7 DR. WHILLANS: Just your extract. The
8 document itself already has a number of 621, if I am
9 not mistaken.

10 MR. M. CAMPBELL: It might be easier for
11 our purposes, Mr. Chairman, to have a separate number
12 for this extract.

13 THE CHAIRMAN: All right, fine.

14 MR. M. CAMPBELL: The third exhibit is
15 Interrogatory 9.14.23, which has to do with hydrogen
16 sulphide releases.

17 THE REGISTRAR: 9.14.23 will be .144.

18 ---EXHIBIT NO. 520.144: Interrogatory No. 9.14.23.

19 MR. M. CAMPBELL: And the next exhibit is
20 Interrogatory 9.22.98, which has to do with radiation
21 exposure.

22 THE REGISTRAR: 9.22.98 is .145.

23 ---EXHIBIT NO. 520.145: Interrogatory No. 9.22.98.

24 MR. M. CAMPBELL: The next is
25 Interrogatory 9.6.17, having to do with uranium miners.

1 THE REGISTRAR: 9.6.17 is .146.

2 ---EXHIBIT NO. 520.146: Interrogatory No. 9.6.17.

3 MR. M. CAMPBELL: The next is the AECB
4 document respecting the new ICRP 60 recommendations. I
5 don't believe that's an exhibit. I don't believe
6 that's been filed.

7 THE CHAIRMAN: You think it has already
8 been filed.

9 MR. M. CAMPBELL: I am asking Ms. Harvie.

10 MS. HARVIE: Well, I don't recognize it,
11 perhaps Dr. Whillans can help us here.

12 DR. WHILLANS: I'm not sure but I don't
13 think -- this is C-122; right?

14 MR. M. CAMPBELL: That's correct.

15 DR. WHILLANS: I don't think it has been.

16 MR. D. POCH: Mr. Chairman, I can be of
17 help. I think it's part of Exhibit 570 filed by IPPSO.

18 THE CHAIRMAN: 570?

19 MR. D. POCH: Yes.

20 MS. HARVIE: Thank you.

21 THE CHAIRMAN: Perhaps it should be, the
22 extract should be given a different number.

23 MR. M. CAMPBELL: Fair enough.

24 THE REGISTRAR: 654, Mr. Chairman.

25 THE CHAIRMAN: I think you have given 654

1 out.

2 THE REGISTRAR: I have lost it.

3 THE CHAIRMAN: Just so you don't lose it,
4 654 is the letter addressed to Mr. Schwartz from
5 Ontario Hydro, to Mr. McCredie of Ontario Hydro.

6 THE REGISTRAR: Thank you, Mr. Chairman.
7 I found it, yes. 655.

8 [10:55 a.m.]

9 ---EXHIBIT NO. 655: AECB document respecting the new
10 ICRP 60 recommendations.

11 MR. M. CAMPBELL: The next is an article
12 from the Lancet, dealing with radon as a causative
13 factor in leukaemia.

14 THE REGISTRAR: 656.

15 ---EXHIBIT NO. 656: Article from the Lancet, dealing
16 with radon as a causative factor in
leukaemia.

17 MR. M. CAMPBELL: The next is
18 Interrogatory 9.17.2 having to do with hydrogen
19 sulphide emissions.

20 THE REGISTRAR: That is .147.

21 ---EXHIBIT NO. 520.147: Interrogatory No. 9.17.2.

22 MR. M. CAMPBELL: And the next document
23 is Interrogatory 9.17.3 having to do with hydrogen
24 sulphide standards, emission standards.

25 THE REGISTRAR: 9.17.3 is .148.

1 ---EXHIBIT NO. 520.148: Interrogatory No. 9.17.3.

2 MR. M. CAMPBELL: The next is an extract
3 from the Porter Commission, there are two parts to
4 that. The first part is a portion of the executive
5 summary, and the second portion is a reference to
6 hydrogen sulphide.

7 I thought they could go in as one. And I
8 gather the complete Porter Commission Report has been
9 filed as an exhibit earlier and I thought it would be
10 easier for the Board just to have this excerpt.

11 THE REGISTRAR: Give it a number, Mr.
12 Chairman?

13 THE CHAIRMAN: Yes, please.

14 THE REGISTRAR: 657.

15 ---EXHIBIT NO. 657: Portion of executive summary and
16 reference to hydrogen sulphide from
Porter Commission Report.

17 MR. M. CAMPBELL: The next is an extract
18 from the Annals of the ICRP. The extract is an article
19 by a Dr. A.C. Upton, it's entitled: Risk Estimates for
20 Carcinogenic Effects of Radiation. It's from the
21 Volume 22, 1991 of the Annals of the ICRP.

22 I wonder if that could be made an
23 separate exhibit as well.

24 THE REGISTRAR: That will be No. 658.

25

1 ---EXHIBIT NO. 658: Article by Dr. A. C. Upton
2 entitled: Risk Estimates for
3 Carcinogenic Effects of Radiation from
 Volume 22, 1991 of the Annals of the
 ICRP.

4 MR. M. CAMPBELL: And the next is an
5 article from the same volume, also ICRP annals
6 entitled: Low Dose Radiation Epidemiological Studies,
7 An Assessment of Methodological Problems by a Dr.
8 Modan.

9 Because I will be referring to these
10 articles on several occasions, I thought it might be
11 best to have two separate exhibit numbers, even though
12 they are from the same volume.

13 THE CHAIRMAN: Right.

14 THE REGISTRAR: That will No. 659.

15 ---EXHIBIT NO. 659: Article entitled: Low Dose
16 Radiation Epidemiological Studies, An
17 Assessment of Methodological Problems by
 Dr. Modan from Volume 22, 1991 of the
 Annals of the ICRP.

18 MR. M. CAMPBELL: The next is an extract
19 again from the Hare Report, in this case it's just the
20 first two pages of one of the chapters -- one of the
21 appendices of the Hare Report, an extract from the
22 technical appendix.

23 THE REGISTRAR: That will be No. 660.

24 ---EXHIBIT NO. 660: Two-page extract from technical
25 appendix of Hare Commission Report.

1 MR. M. CAMPBELL: The next document is an
2 article on dosimetry, particularly in connection with
3 the Japanese experience.

4 THE REGISTRAR: No. 661.

5 ---EXHIBIT NO. 661: Article by Drs. Preston and
6 Pierce on dosimetry in connection with
7 Japanese experience produced by Radiation
Effects Research Foundation.

8 MR. M. CAMPBELL: It's an article by Drs.
9 Preston and Pierce from the Radiation Effects Research
10 Foundation.

11 The next document --

12 THE REGISTRAR: Wait, please.

13 MR. M. CAMPBELL: Sorry.

14 THE REGISTRAR: The last one was 662.

15 THE CHAIRMAN: I don't think you have
16 told us about that one yet.

17 MR. M. CAMPBELL: The article on
18 dosimetry is I believe 661.

19 THE CHAIRMAN: Right.

20 MR. M. CAMPBELL: So the next would be an
21 extract -- I'm sorry, an Interrogatory 9.22.32, a table
22 having to do with Ontario Hydro mortality, 1970 to 1988
23 I believe it is.

24 THE CHAIRMAN: That will be a 520 number
25 then, rather than 662?

1 MR. M. CAMPBELL: Yes.

2 THE REGISTRAR: 520.149.

3 ---EXHIBIT NO. 520.149: Interrogatory No. 9.22.32.

4 MR. M. CAMPBELL: The next document is
5 from the National Radiological Protection Board in the
6 U.K. November, 1987, Interim Guidance on the
7 Implications of Recent Revisions of Risk Estimates and
8 the ICRP 1987 COMO statement, this is of Great Britain
9 on standards. I believe that would be 662.

10 THE REGISTRAR: No. 662.

11 ---EXHIBIT NO. 662: Document from National
12 Radiological Protection Board, U.K.,
13 November, 1987, entitled: Interim
14 Guidance on the Implications of Recent
15 Revisions of Risk Estimates and the ICRP
16 1987 COMO Statement.

15 MR. M. CAMPBELL: Only a few more to go,
16 Mr. Chairman. The next document is an extract from the
17 United States Environmental Protection Agency called
18 Risk Assessment Methodology.

19 THE REGISTRAR: No. 663.

20 ---EXHIBIT NO. 663: Extract from United States
21 Environmental Protection Agency entitled:
22 Risk Assessment Methodology.

22 MR. M. CAMPBELL: The next response to
23 Interrogatory 9.2.9 which is a bundle of
24 correspondence, memoranda and so on from Ontario Hydro
25 dealing with infant leukaemia and, in addition, I have

1 incorporated in that material a reference to a study of
2 childhood leukaemia in Shanghai.

3 THE REGISTRAR: That interrogatory will
4 become .150.

5 ---EXHIBIT NO. 520.150: Interrogatory No. 9.2.9.

6 MR. M. CAMPBELL: The next document is a
7 document of ACNS, Comparative Energy Systems. I
8 believe that may be an exhibit already, I'm not
9 certain.

10 THE REGISTRAR: Is it?

11 MR. M. CAMPBELL: I'm just trying to...
12 I gather it's attached to an interrogatory. I don't
13 know whether it should be given a special exhibit
14 number.

15 THE CHAIRMAN: Perhaps we can give it a
16 number now and then it will flow through here.

17 THE REGISTRAR: No. 664.

18 ---EXHIBIT NO. 664: Document from ACNS, Comparative
19 Energy Systems.

20 MR. M. CAMPBELL: And my last exhibit is
21 a document from the State of Massachusetts having to do
22 with proposed standards.

23 THE REGISTRAR: No. 665.

24 ---EXHIBIT NO. 665: Document from State of
25 Massachusetts having to do with proposed
standards.

1 MR. M. CAMPBELL: And two other documents
2 I intend to refer to, one is Exhibit 554 having to do
3 with tritium releases from the Pickering nuclear
4 generating station and Birth Defects and Infant
5 Mortality in Nearby Communities, an AECB report which I
6 have mentioned to Mr. Lucas.

7 And another document, again I'm not
8 certain whether or not it is an exhibit, Childhood
9 leukaemia Around Canadian Nuclear Facilities, Phase 2,
10 Final Report also document preferred for the AECB.

11 We believe it's attached to an
12 interrogatory but, again, I don't have that.

13 THE REGISTRAR: Did you just call out an
14 interrogatory number?

15 MR. M. CAMPBELL: We don't have the
16 interrogatory number, I'm afraid.

17 MS. HARVIE: I think actually we have
18 just discovered it is an exhibit and we are trying to
19 track down the number.

20 MR. M. CAMPBELL: Oh. If it's of any
21 comfort, Mr. Chairman, I think the pile is somewhat
22 daunting but, in many cases, I intend to only refer to
23 one or two of paragraphs. I have alerted Dr. Whillans
24 to those paragraphs so that we won't be wading through
25 a great deal of material.

1 DR. WHILLANS: And I have lost only one
2 of them.

3 MR. M. CAMPBELL: And my thanks to Ms.
4 Harvie who assisted in getting all of this material
5 copied in fairly short notice. So it's very helpful.

6 Just to give you a brief outline of my
7 cross-examination, I intend to focus almost exclusively
8 on Exhibit 507, the materials relating to environmental
9 and health effects.

10 I thought I would touch very briefly on
11 the issue of Carbon-14 which one of my colleagues asked
12 me to canvas very briefly with Dr. Whillans.

13 And then I thought I would focus on dose
14 estimates, risk estimates and standard setting, and
15 then I would focus very briefly on hydrogen sulphide.
16 I gather Eugene Bourgeois would be spending some time
17 on that later.

18 And one or two questions on emergency
19 response. I don't intend to go into the technical
20 chances of an emergency occurring, rather the response
21 of the health care system.

22 And lastly I will touch very briefly on
23 one or two of the recommendations in the Porter Report.
24 That gives you a very rough outline of where I'm going.

25 I thought to start that we might just

1 deal very briefly with the issue of Carbon-14 which I
2 gather was referred to earlier in evidence before you
3 in Volume 135, page 23634 of the transcript, where I
4 believe Dr. Connell put questions to Dr. Whillans
5 respecting Carbon 14, and I was asked to put a
6 follow-up question on this point.

7 CROSS-EXAMINATION BY MR. M. CAMPBELL:

8 Q. And just to give you a brief
9 synopsis, I believe Dr. Whillans stated that the
10 atmosphere contains approximately 140,000
11 terabecquerels of Carbon-14, the ocean contains 9.3
12 million terabecquerels, he stated that cosmic rays
13 create approximately 1,400 terabecquerels per year on
14 the earth, and nuclear power creates 600.

15 And the statement was that nuclear is
16 insignificant compared to the world inventory, and my
17 question is whether, in fact, that is accurate.

18 My experts inform me that they made a
19 rough calculation of the decay of Carbon-14 based on a
20 half life of 5,700 years and this suggests that the
21 decay rate approximately equals the contribution from
22 cosmic rays. So the system is roughly an equilibrium.

23 And our statement goes on to say, that if
24 nuclear power is added in the system becomes unbalanced
25 and the amount of Carbon-14 must rise, and eventually a

1 new higher equilibrium where total production equals
2 total K would arise.

3 And I have shared this statement with Dr.
4 Whillans so he has a sense of it.

5 The extra 600 terabecquerels a year does
6 not sound like much according to our expert, but over
7 100 years at the current rate of production it's nearly
8 60,000 terabecquerels, nearly 50 per cent of the
9 current amount in the atmosphere, and if additional
10 CANDUs are added, the amount will rise further.

11 And so our question is whether nuclear
12 power over the next 100 years is, in effect, shifting
13 the natural equilibrium of Carbon-14 towards what could
14 be a significantly higher concentration in the
15 environment.

16 And I asked Dr. Whillans to comment on
17 that point.

18 DR. WHILLANS: A. Well, first, if I did
19 say that Carbon-14 was insignificant then I was
20 incorrect. I think what I said, or should have said,
21 was that it doesn't contribute significantly to doses.

22 Clearly, since nuclear power generation,
23 and particularly heavy water reactors, are a
24 substantial fraction of the annual source, the rest
25 being cosmic generation, that in the long term it would

1 make a difference.

2 And when I made that statement I was
3 thinking particularly that there is such a large
4 inventory, the 9.3 million terabecquerels that you
5 referred to, that it doesn't contribute presently in a
6 significant way to the Carbon-14 dose.

7 And I did mention that we don't believe
8 it's insignificant. We have taken some actions to
9 reduce Carbon-14 emissions, and I mentioned that the
10 ACRP has a working group which is looking specifically
11 at what significance it does have and we participate in
12 that as well.

13 Now, with respect to your calculations,
14 it might be useful if we looked at Exhibit 620 which
15 was the copy of the overheads I used when I was
16 answering Dr. Connell's question.

17 Q. Perhaps I could just share with Ms.
18 Harvie. I don't believe --

19 MS. HARVIE: Do you have one?

20 MR. M. CAMPBELL: No, I don't believe I
21 do.

22 DR. WHILLANS: What was shown on the
23 first page of this exhibit, for the purposes of giving
24 a perspective I guess, was a division of the world
25 inventory into the atmospheric, which as you said is

1 140,000 terabecquerels, and the carbon that's present
2 in the ocean. And this itself is a bit of a
3 simplification of the detailed inventory distribution
4 that's given in the NCRP report No. 81, Carbon-14 in
5 the Environment, and I referred to that before.

6 In fact, the ocean is divided in that
7 report into several categories, and there's a surface
8 layer which contains - I will refer to my notes - just
9 to give you a perspective, approximately the same
10 inventory as the atmosphere, and the bulk of that 9.3
11 million is in the deep ocean.

12 [11:15 a.m.]

13 The calculation of the impact of an input
14 from, say, nuclear power generation requires you to
15 analyze these compartment models and look at the
16 overall.

17 And because there are a number of models
18 it's reasonably complicated, but if I could just sort
19 of simply it. If we took the simple case, that the
20 inventory of 9.44 million terabecquerels acted as a
21 single compartment, and this is a simplification, then
22 it's true that with time the inventory is going to
23 rise. It's going to rise whether or not there is
24 nuclear power generation because there is input at a
25 slightly greater rate than there is decay at the

1 moment. But they are, as your writer said, roughly in
2 equilibrium.

3 But I think the point I would make here
4 is that the rise is going to occur with a half time of
5 the half life of carbon, 5,730 years. So we are
6 talking an increase of perhaps, by my calculations,
7 about 25 or 30 per cent over some tens of thousands of
8 years.

9 So on that simple model, and I present
10 that just because it's one of the simple models where
11 the activity in the ocean is also in equilibrium with
12 the new inputs. It will be a very long time before it
13 has a significant impact -- thousands of years, before
14 it has a significant impact.

15 Now I accept that that is perhaps too
16 simple a model and the impact of the --

17 MR. M. CAMPBELL: Q. Before you go on to
18 the next, more complicated model, can I ask you about
19 trying--

20 DR. WHILLANS: A. It's a simpler one,
21 actually.

22 Q. --to limit your ranges to the 100
23 years suggested by my expert, if you can, because I
24 gather the concern is --

25 A. I am disagreeing I think with what

1 your expert has said.

2 Now, in that model the impact is going to
3 take place over a very long time. But that model is
4 too simple because certainly the activity in the deep
5 ocean is not exchanging immediately with the
6 atmospheric carbon, which is what gives us dose.

7 So if we took a model in which the
8 atmospheric, 140,000 terabecquerels was exchanging,
9 then we would come to a conclusion similar to what your
10 author has said.

11 I think the problem is that that model is
12 also too simple. The report 81 I referred to points
13 out that the atmosphere exchanges with what I referred
14 to as the surface layer of the ocean carbon at about 13
15 per cent a year. So when we are talking about a time
16 scale of 100 years, which is the number that was used
17 here, a significant amount of that input has
18 transferred into the deep ocean. And so it's wrong,
19 for example, to talk about the generated activity being
20 nearly 50 per cent of the current amount in the
21 atmosphere. It's not wrong technically, but it doesn't
22 have the meaning I think that is intended.

23 Q. But if you factor in the proportion
24 which is transferred from ocean to atmosphere --

25 A. The other way, actually.

1 Q. From atmosphere to ocean, if you
2 factor that in, what is the extent of the
3 disequilibrium? Can you give us any estimate of that?

4 A. Since you gave me this last night, I
5 haven't had a chance to do the complete solutions.

6 Q. I think you are doing awfully well,
7 quite frankly.

8 A. I am trying to get you a sort of
9 perspective on why I can't agree with the statements
10 that were provided by your writer. And I think the
11 problem is that it does ignore the fact that the
12 atmospheric inventory is not over the course of, say,
13 100 years in equilibrium -- sorry, is not the only sink
14 for nuclear-generated carbon. A substantial amount of
15 that, 13 per cent per year, goes to the deep ocean.

16 So it is being driven into this larger
17 pool which I described earlier, and in the extreme case
18 where that was the only thing we worried about, the
19 time scale would be very much longer.

20 So I guess what I am saying is that I
21 don't believe it's insignificant certainly in the
22 long-term, and if there were more carbon generation, it
23 would elevate the contribution of carbon-14 to
24 background dose. Background dose is about 14
25 millisieverts -- sorry, 14 microsieverts per year, .014

1 millisieverts, a small fraction of background but
2 measurable.

3 And it is true that in the long-term it
4 would continue to increase. But I think it could be
5 much longer than the time scale that is suggested here.

6 And again, this is exactly the kind of
7 thing that ACRP Committee is looking into and it is the
8 reason that we, for example, have switched our annulus
9 gas from nitrogen to CO(2) to reduce the contribution
10 from that source. So we don't ignore it, but I think
11 that the calculation here is not correct.

12 Q. In my copy of Exhibit 620, which I
13 just borrowed from Ms. Harvie, there are two arrows
14 inked in, one showing from the atmosphere to the ocean
15 and from the ocean to the atmosphere. Did that appear
16 in the original exhibit?

17 A. Yes, it does. It does in mine,
18 anyway.

19 Q. What you are really saying is that
20 for at least that component which comprises the ocean
21 you should look at that in terms of layers?

22 A. That's right.

23 Q. So the top layer would be that
24 portion of the ocean which interacts with the
25 atmosphere.

1 A. 13 per cent per year.

2 Q. And what depth of ocean are we
3 speaking about? And my next question would be, the
4 proportion of the 9.3 million terabecquerels which is
5 in that?

6 A. Yes, okay. The surface layer as
7 given in report 81 extends to a depth of about 75
8 metres, and it contains, by my calculation, about
9 169,000 terabecquerels, so slightly larger than the
10 atmospheric inventory.

11 Q. So taking the atmospheric and the top
12 portion of the ocean, you are dealing with -- what was
13 the total of terabecquerels for carbon-14?

14 A. 310,000.

15 Q. So that is roughly where for the bulk
16 of the carbon-14 --

17 A. That's right. But then, there is, as
18 you can imagine, the rest of the 9.3 million in a part
19 of the ocean which exchanges at about, the estimate
20 here is 2 to 8 per cent per year. So in the time scale
21 of decay of carbon, for example, 5,700 years, an awful
22 lot of exchange is going on and there is time for
23 activity to circulate throughout all these pools.

24 Q. Over extended periods of time, but
25 over the 100 years considered by my expert --

1 A. As I said, over 100 years at 13 per
2 cent per year, every six or seven, seven or eight years
3 on average, you are getting exchange. So there is time
4 for lots of exchange even on the sale of 100 years.

5 Q. Now, again, in terms of the effect on
6 mankind, you would find fishing for purposes of food,
7 possible sources of rainfall, and so on, coming from
8 that layer in the ocean, would you not, from that upper
9 layer, a larger portion?

10 A. Well, I would suppose so, yes.

11 Q. So you are having, to that level at
12 least, potential for disequilibrium of the environment;
13 is that correct?

14 A. I think I am saying even the 2 to 8
15 per cent on the time scale of 100 years means that it
16 is going to be mixing with the full pool.

17 One of my colleagues pointed out to me
18 that on the last page of Exhibit 620 is a graph again
19 taken from this report 81 which gives some indication
20 of the response, and in this particular case to the
21 large input of carbon-14 from weapons testing, it's
22 marked as followed in the middle curve here, mainly
23 during the 1950s and early 1960s. And you can see that
24 there was large input, large increase, and this is the
25 dose rate, millirads per year, but it's the dose rate

1 which results from activity from that atmospheric
2 component. There was a large increase because of the
3 input of weapons which is greater than the numbers we
4 are talking about from nuclear power generation.

5 But it has decayed away with a half time
6 of perhaps 15 years, and that is not radioactive decay,
7 that's decay into the deep ocean.

8 So, there is substantial decay, even on
9 the scale of tens of years, which is not radioactive
10 decay; it's loss into this very large sink.

11 Q. Decay in the sense that it's going
12 into the larger sink; not decay in the sense --

13 A. That's right, not radioactive decay
14 but loss from the atmosphere where it is available to
15 give dose.

16 Q. So conceivably over a longer period
17 of time the sink will be more and more radioactive, I
18 presume.

19 A. That's right. Over long periods of
20 time we would bring the deep ocean into equilibrium,
21 but we are talking about many tens of thousands of
22 years.

23 Q. Let me just raise one other point
24 which was touched on in the exchange in that answer to
25 that question. I am referring to page 23636 of the

1 transcript where I believe you defined mean local dose,
2 and I just want to recall for later on in our
3 cross-examination the response where you spoke of the
4 UNSCEAR defining local as meaning within 100 kilometres
5 and the population which would be within that range.

6 I will tell you the context later my
7 cross-examination, I will ask you about the choice of
8 the 25 kilometre radius which was used for calculating
9 dose and I will ask why you chose that radius as
10 opposed to the 100 set out in UNSCEAR. So that's the
11 reference there.

12 A. Okay. While we are at that
13 reference, I should point out that the roughly 2
14 million is, of course, just I guess an educated guess.
15 We don't have accurate numbers about the population
16 within 100 kilometres.

17 Q. My point is, the choice of 25 as
18 opposed to 100.

19 A. Okay.

20 Q. We can deal with that a little later.

21 A. Sure.

22 DR. CONNELL: If I may just re-enter the
23 discussion briefly.

24 First of all, just to make an
25 etymological point, I much prefer to use the term

1 "steady state" rather than "equilibrium". Equilibrium
2 implies a reversible process and this is not --

3 DR. WHILLANS: Yes, I accept that. I was
4 using the words in the...

5 How do we refer to this? These are your
6 calculations. It doesn't have a number.

7 MR. M. CAMPBELL: That was of the
8 instruction from my expert. I haven't put it in as an
9 . expert.

10 I must say, it's not my expert
11 particularly. I was asked to put questions on that
12 point. So the material from which I was reading is not
13 part of the proceedings.

14 DR. CONNELL: Secondly, Dr. Whillans, the
15 figure of 9.3 million terabecquerels which accounts for
16 most of the C-14 that we know about, do you think or
17 have you been able to demonstrate that that is the
18 steady state level which corresponds roughly to the
19 1,400 terabecquerel per year rate?

20 DR. WHILLANS: I am looking for a
21 calculation that we did as part of this exercise.

22 Well, let me put it this way: If you
23 take a simple single compartment with an input of 1,400
24 terabecquerel per year and allow it to decay only by
25 radioactive decay, so it has a decay rate of, it turns

1 out to 1.2 times 10 to the minus 4 per year, that will
2 build up to an inventory of some 11.7 million
3 terabecquerel.

4 So to the extent that that -- well, I
5 guess we don't know over the geological time whether
6 the production rate has been constant, but to the
7 extent that it is, this means that that inventory has
8 more or less filled both the ocean and atmosphere and
9 it's approximately the right rate.

10 I should also add, actually, I noticed in
11 the report 81 that the molar concentration of carbon,
12 is carbonate, in the deep ocean and in the surface
13 water is almost exactly the same. So that also
14 suggests that things are more or less at steady state.

15 DR. CONNELL: And if you then add to that
16 600 terabecquerels a year production and maintain that
17 indefinitely, the steady state level would rise, but it
18 would not rise proportionately, would it; it would be
19 somewhat less than 40 per cent increase that is -- I am
20 speaking now of many of tens of thousands of years when
21 the new steady state is established, it would not
22 increase by 600 over 1,400, would it, because the decay
23 rate would be proportionately higher.

24 DR. WHILLANS: I think I was just trying
25 to indicate that we are not exactly at steady state

1 now. The steady state value calculated from the
2 current production rate and the known decay rate of
3 carbon is greater than the inventory that is estimated
4 for the ocean and the atmosphere. So over fairly long
5 periods of time we will approach that.

6 Now, we will approach a slightly higher
7 value if the source term is increased by 600. It would
8 be a proportionately higher value, but we are talking
9 about it happening over tens of thousands of years,
10 which is the response time of this total system. It's
11 determined only by radioactive decay.

12 Perhaps your question, I may not be
13 understanding your question. It was directed at the
14 atmospheric inventory which is responsible for dose?

15 DR. CONNELL: No, I was looking at the
16 entire inventory and just stating that I believe that
17 the new steady state, once established, would not be
18 proportional, it would be somewhat less than 6/14ths
19 higher.

20 DR. WHILLANS: Well, perhaps we are not
21 thinking of the same model.

22 If we have the simple model of a single
23 compartment of global carbon with an input of either
24 1,400 or 2,000, terabecquerels per year, decay only by
25 radioactive decay, then I believe the equilibrium level

1 for that would be in the case of 1,400, 11.7 times 10
2 to the 6 terabecquerels, and in the case of 2,000,
3 16.7. It's strictly an input over the decay constant
4 times a time dependent factor.

5 DR. CONNELL: Thank you. I think
6 that's --

7 DR. WHILLANS: But the time dependent
8 factor is the one that contains the half life of
9 carbon.

10 DR. CONNELL: Now, just let me assume
11 without drawing any inferences, but let's assume that
12 the input from nuclear energy persists not indefinitely
13 but only for 100 years, then that would be a relatively
14 minor perturbation of the steady state, I take it?

15 DR. WHILLANS: Yes, I think it would of
16 qualitatively similar to the input of maybe over 15
17 years of follow-up carbon, and you can see that it has
18 decayed away subsequently in the subsequent 20 or 30
19 years. So it would be a relatively minor perturbation,
20 yes, I agree.

21 DR. CONNELL: So after five or 10,000
22 years the difference might be quite negligible.

23 DR. WHILLANS: That's right. I agree.
24 Yes.

25 DR. CONNELL: Thank you.

1 MR. M. CAMPBELL: Q. Just to follow up
2 on Dr. Connell's point that's assuming that the current
3 rate of nuclear generation; is that correct?

4 We are not assuming an increase in the
5 number of units and so on. And I take it that would be
6 based on a cessation of nuclear after a period of 100
7 years.

8 DR. WHILLANS: A. Well, Dr. Connell
9 described his own assumption, but I assumed that he
10 believed that on a time scale of several hundred years
11 other sources of power might become available.

12 THE CHAIRMAN: Mr. Campbell, I wonder if
13 we could take the break now.

14 MR. M. CAMPBELL: Thank you, sir.

15 THE CHAIRMAN: We will break for 15
16 minutes.

17 THE REGISTRAR: Please come to order.
18 This hearing will recess for 15 minutes.

19 ---Recess at 11:30 a.m.

20 ---On resuming at 11:55 a.m.

21 THE REGISTRAR: Please come to order.
22 This hearing is again in session. Be seated, please.

23 MS. HARVIE: Mr. Chairman, we did find
24 our list of exhibits and the last document that Mr.
25 Campbell referred to, being AECB Final Phase 2 Report

1 on Childhood Leukaemia has indeed been filed as an
2 exhibit No. 520.17. It was an attachment to
3 Interrogatory 9.9.26. In addition --

4 THE CHAIRMAN: It wasn't given an exhibit
5 number, I don't believe.

6 MS. HARVIE: No, not aside from the
7 original exhibit number.

8 THE CHAIRMAN: No.

9 MS. HARVIE: 520.17. I understand as
10 well that Mr. Penn has some information arising out of
11 this morning's cross-examination by Ms. Spoel.

12 THE CHAIRMAN: Thank you.

13 MR. PENN: Mr. Chairman, I undertook to
14 check at the break, for Ms. Spoel, the budget for the
15 CANDU owners group in 1992.

16 The total budget is \$184 million, of
17 which Ontario Hydro's contribution is about 50 per
18 cent. That compares in 1991 of a total of 173.2
19 million where Hydro's contribution was 81.9 million.

20 And also, Ms. Spoel asked me in 1990 what
21 part of the 102.3 million was CANDU owners group and
22 the answer is 74.12 million, and the balance between
23 74.12 and 102.3 is discussed in interrogatory 8.38.2.

24 THE CHAIRMAN: 8.38...?

25 MR. PENN: .2 and is where it describes

1 Ontario Hydro's research division annual budget and
2 splits it into the amount of money spent on nuclear
3 maintenance, demand management, environment and the
4 electrical power system as a whole.

5 So I hope that that provides all the
6 information that Ms. Spoel would like.

7 THE CHAIRMAN: All right.

8 MS. HARVIE: We will undertake to call
9 Ms. Spoel to make sure this discussion is brought to
10 her attention.

11 THE CHAIRMAN: Thank you, Ms. Harvie.
12 And then we will have a number for 8.38.2, I guess.

13 THE REGISTRAR: 8.38.2 is .151.

14 THE CHAIRMAN: Thank you.

15 ---EXHIBIT NO. 520.151: Interrogatory No. 8.38.2

16 THE CHAIRMAN: All right. I think when
17 we finish this hearing we will talk in nothing but
18 numbers. Mr. Campbell.

19 MR. M. CAMPBELL: Thank you.

20 Q. Just a quick question to understand
21 the authors of Exhibit 507. I take it this report or
22 these materials were prepared by a group within Hydro;
23 is that correct? Can you just tell me briefly who
24 prepared the report?

25 MR. JOHANSEN: A. Yes, that's right.

1 Q. Which group? What's the name of the
2 group that prepared it, division or...

3 A. Well, I guess it was prepared by a
4 group of people drawn from different departments,
5 mostly I would say drawn from the design and
6 development generation division, but some also
7 representing the health and safety division and the
8 nuclear operations division and power system planning
9 division. So, it was indeed a corporate team.

10 Q. Did members of this panel contribute
11 to this report or these materials?

12 A. Our earlier testimony indicated that
13 most of us, that is I guess there were only three of us
14 that had any involvement, Mr. King, myself and Dr.
15 Whillans, most of that was simply in a review capacity.

16 Q. Well, let me --

17 A. I believe Dr. Whillans had some input
18 to an appendix which he can speak to himself, I guess.

19 Q. Fair enough.

20 A. But it was largely prepared by this
21 other team.

22 Q. I just want to cut to the real point
23 of this and, that is, members of this panel have
24 reviewed and, so to speak, signed off or accepted the
25 broad conclusions of these materials; is that correct?

1 A. Well, I'm not sure that sign off is
2 necessarily the privilege that we were given. We had
3 an opportunity to review, we commented, some of the
4 comments were taken into account.

5 Some I assume the authors didn't have
6 time to take into account because of deadlines, but we
7 certainly had an opportunity to review, yes.

8 THE CHAIRMAN: You want to know whether
9 they adopt the contents, is that what you want to know?

10 MR. M. CAMPBELL: A simple question.

11 THE CHAIRMAN: I take it that's correct.

12 MR. JOHANSEN: Yes, that's generally
13 true.

14 MR. M. CAMPBELL: Q. I would like to put
15 this question Dr. Whillans, if I may, it's a matter
16 which we also reviewed the other evening and I will be
17 referring to a number of exhibits, Exhibit 659 the
18 article from the Annals, also Exhibit 661, dosimetry,
19 and the other article also in the Annals, Exhibit 658.

20 And I'm going to begin with a very brief
21 comment to try to set the context of this question.

22 As I examine Exhibit 507 as a whole I
23 would say that it's an extremely valuable document in
24 putting Hydro's case before the Board. But I'm
25 submitting that it's less valuable as a guide to this

1 Panel on public policy issues and, in particular, in
2 the way that it has understated the range of
3 uncertainty which is inherent in some of the
4 conclusions that have been drawn.

5 And in making that statement I intend to
6 put some of the caveats which I find in ICRP and
7 question whether these have been adequately explained
8 in this document.

9 I am not going beyond your assumptions to
10 other assumptions which I might put later on in these
11 proceedings, I am trying to deal with your assumptions
12 and understanding of the basis of this.

13 And the first exhibit I would like to
14 turn to is the article by Dr. Modan, 659. Now, this
15 may not appear in the photocopy which I have given, but
16 I gather that these papers were approved by the ICRP;
17 is that correct, Dr. Whillans?

18 DR. WHILLANS: A. Well, I have the full
19 copy here. Perhaps I could just tell you what their
20 view of it was.

21 Q. Well, the very first sentence at the
22 very -- underneath the title:

23 This paper was prepared as part of
24 the work of the risk task group committee
25 of ICRP and approved by the task group

1 and the committee.

2 A. Yes, there was a task group set up in
3 the late 1980s by ICRP to review the changes in risk.

4 These people ultimately recommended the
5 changes that appear in ICRP 60, and I am quoting from
6 the preface to the annals that you provided:

7 In order to provide a complete
8 record of the biological basis of the
9 recommendations, the preparation of five
10 papers by individual members of the task
11 group was agreed upon. These papers were
12 subsequently reviewed first by the other
13 members of the task group and by all the
14 members of Committee 1 of ICRP. Thus,
15 these papers are approved for publication
16 by Committee 1 of ICRP.

17 So, I think this is provided to give,
18 particularly users of ICRP 60, the new recommendations,
19 more information about how ICRP arrived at these
20 numbers.

21 Q. Well, I think it could be fair to say
22 that Dr. Modan questions the methodological problems
23 which arise in studies having to do with low-dose
24 radiation; is that correct.

25 This is his thrust, and he canvasses a

1 number of potential sources of error including
2 inadequate dosimetry samples, adequate controls,
3 extraneous effects, socio-geographical confounders, all
4 of these things.

5 A. Well, I don't know that that's quite
6 a fair way to put it.

7 Q. Well, it's right from the contents, I
8 mean.

9 A. Yes, but I am just telling you that
10 he is presenting a summary of the uncertainties which
11 are accepted by all the members of Committee 1 I am
12 sure.

13 We know there are uncertainties, and he's
14 itemizing them here, he's referencing the contrary
15 views, he's referencing the views that support the
16 recommendations, and I think he's just trying to
17 provide an assessment of methodological problems as the
18 title says.

19 Q. Well, if we look at page 69
20 Prospects, I would just like to read in his general
21 conclusions.

22 The results of low-dose radiation
23 studies discussed in the preceding
24 paragraphs, can be divided into five
25 groups:

1 And he divides them into five groups.

2 And then his last two paragraphs:

3 Thus, at the present time, with the
4 possible exception of the studies of
5 prenatal x-irradiation, methodological
6 limitations detailed above preclude the
7 use of data coming from low-dose
8 radiation epidemiological studies for
9 risk estimation.

10 And then he speaks of the Hanford study
11 and then his last sentence:

12 It will probably take at least
13 another decade before more refined data
14 might emerge from the follow-up of such
15 modern major nuclear accidents as
16 at Chernobyl. Such data, in either
17 direction, would hopefully shed more
18 light on the complexity of this issue.

19 Now, my question is: Has the
20 reservations expressed by Dr. Modan, have they been
21 expressed anywhere in Exhibit 507 or are they taken
22 into account in Exhibit 507 or are they articulated in
23 507?

24 A. Let's be clear. The reservations
25 he's talking about are with respect to:

1 ...methodological limitations
2 detailed above preclude the use of data
3 coming from low-dose radiation
4 epidemiological studies for risk
5 estimation.

6 All right. The main estimates in ICRP
7 and those adopted in 507 are not based on those
8 low-dose epidemiological studies, they are based on
9 primarily the Japanese experience but also other
10 studies primarily at high doses, and the reason is that
11 at low doses effects cannot be distinguished from
12 background.

13 Q. Okay. Well, let's turn to the
14 Japanese studies and this is Exhibit 661, and I think
15 we have to stick to the left-hand margin, at least as
16 far as I am concerned.

17 If we look at page 1, and I am really
18 only interested in the second and third paragraphs. As
19 a brief synopsis, the last sentence shows that there is
20 quite a distinction between results based on old
21 dosimetry and new dosimetry, so that one could say, as
22 of the date of this article which is--

23 A. 1987.

24 Q. --1987, that one has to revisit the
25 early Japanese data in light of this study; is that

1 correct?

2 A. Oh, yes, and that was certainly done
3 in the 1990 ICRP publication.

4 Q. Now, is that incorporated again in
5 your Exhibit 507 as a --

6 A. Well, certainly. To the extent that
7 we use the new ICRP risk numbers, we have taken that
8 into account, yes.

9 Q. The new ICRP risk numbers of 1990?

10 A. Actually published in '91, I believe.
11 They are called the 1990 recommendations.

12 Q. So that also has been incorporated?

13 A. Yes.

14 Q. Well, let me ask you another question
15 about this, and this has to do with ICRP itself. At
16 page 1.1 of Exhibit 507, the second paragraph --

17 A. Sorry, page number again please?

18 Q. It's Exhibit 507 page 1.1,
19 Introductions.

20 A. 1.1, yes.

21 Q. I am going to put to you the question
22 which appeared -- question which is arising from the
23 middle sentence of that second paragraph where it says:

24 Due to conservatisms in the ICRP

25 risk estimates and in dose estimates the

1 fatalities derived should be regarded as
2 hypothetical.

3 And I want to ask you about
4 conservatisms, particularly in the light of ICRP's
5 practice of extrapolating from high dose to low dose
6 and you recall I discussed the chart with you.

7 Does that sentence, first of all,
8 suggest -- the reference to conservatisms, does that
9 suggest that there is a poor confidence level in the
10 estimates, in your estimation?

11 A. Not in the estimates per se. I think
12 there is accepted uncertainty in whether the numbers
13 apply at low doses and dose rates.

14 In many experimental systems the
15 response, induction of cancers or other kinds of
16 responses, is less at low doses and dose rates than
17 would be predicted from high dose and dose rate
18 exposures.

19 We don't have good human data as you
20 described in Modan's article and there is a source of
21 uncertainty that we may be overestimating.

22 Q. Well, so that there is a possibility
23 of error in either direction?

24 A. Yes.

25 Q. And can you give me any range of that

1 error? I know it's a huge question, but I...

2 A. Well, I think in previous evidence I
3 said that, in my understanding, the uncertainty in the
4 risk estimate as applied at low doses and dose rates is
5 probably a factor of 3 or so.

6 Clearly when you make such an estimate
7 you take into account only known sources of uncertainty
8 and this includes residual uncertainty in the dosimetry
9 for the bomb survivors, it includes the uncertainty in
10 extrapolating lifetime risks for populations that 40
11 per cent are still alive, and it includes
12 extrapolations from those particular Japanese
13 populations mainly to other populations, and it
14 includes an estimate of the extrapolation from high
15 doses and dose rates to low doses and dose rates.

16 And the number that is given, for
17 example, by Dr. Sinclair who is chairman of Committee 1
18 of the ICRP and former head of the NCRP is the order of
19 a factor of 3 or so. But that isn't to say it couldn't
20 be 4 and it couldn't be 2.

21 Q. Well, let me ask you about the
22 concept of extrapolating risk estimates from high doses
23 to low doses. You have the experience of the Japanese
24 atomic bomb survivors, the high dose, and you
25 extrapolate that to low dose.

1 Now, you can do that perhaps in three
2 ways: One is called the supralinear hypothesis, which
3 starts and gives you a higher range of fatal cancers at
4 the low dose, is that correct, that type of--

5 A. Yes.

6 Q. --a line which gives you a higher
7 number at low dose?

8 A. Yes, yes.

9 Q. Or you can follow the linear
10 non-threshold hypothesis which gives you almost, not
11 quite a 45 degree angle, but a straight line virtually?

12 A. Yes.

13 Q. And then thirdly you have the linear
14 quadratic hypothesis which gives you a lower number of
15 fatalities at the low dose. So you have those three.

16 A. Those are 3. There are others.

17 Q. Those are three.

18 A. Yes.

19 Q. So I understand that generally
20 speaking, the nuclear industry uses either the linear
21 or the linear quadratic hypothesis which gives the
22 lowest number of cancer fatalities. Now, that's not a
23 conservative estimate in my view.

24 A. Well, as I said, those are three. I
25 mean, certainly a threshold hypothesis gives an even

1 lower number. If we assume that there is a threshold
2 of 20 millisieverts, then we would assume there is no
3 risk below that level.

4 Q. Which is used by Hydro in its
5 calculations?

6 A. Hydro accepts the recommendations of
7 the ICRP. I guess I should also point out, we are
8 talking about extrapolation from high doses.

9 The atomic bomb survivors data extends
10 over all doses and in fact is a statistically
11 significant elevation of cancer risk even at 20
12 millisieverts, and so that's above the range of the
13 normal occupation exposure, but not order of magnitude
14 above, and extrapolation is of a line which is using
15 that data as well.

16 Q. But the ICRP tends surely; is that
17 correct, to use the linear or linear quadratic
18 hypothesis, is that --

19 A. Well, the ICRP uses a linear dose
20 response for solid cancers and a linear quadratic
21 response for leukaemia because that is what this
22 statistical analysis of the Japanese data says in a
23 statistical sense.

24 In other words, you can demonstrate with
25 the leukaemia data that a linear curve does not

1 adequately describe the data; you cannot do that for a
2 typical solid cancer.

3 Q. But there is debate over the
4 appropriate manner in which this should be
5 extrapolated, and I gather that evidence is mounting
6 that the supralinear hypothesis is more accurate; that
7 is to say, you extend from the high dose to a greater
8 number of fatalities?

9 A. Well, I don't accept that.

10 Q. No. Well, let ask you about --

11 A. Maybe I should put one qualification
12 and I am sure this is not what you have in mind, but in
13 my evidence I talked about linear hypothesis.

14 There is one circumstance in which I
15 think present scientific evidence suggests the
16 possibility of a supralinear hypothesis, and that is
17 only for neutron exposures.

18 That's not what we are generally talking
19 about, but there certainly is something not yet
20 understood about low dose rate neutron exposures, and
21 so I make that qualification, but that doesn't affect
22 the --

23 Q. Well, let me ask you about dose rates
24 while we are on that then. The dose estimates depend
25 on measurements which are used which are done using

1 thermoluminescent dosimeters; is that correct?

2 A. Which dose estimates?

3 Q. These measure direct gamma radiation
4 of energy greater than 50 kiloelectron volts; is that
5 right?

6 A. Well, if you are thinking of the
7 Japanese population, for example, there are very
8 different methods that were used to estimate doses.

9 Q. Well, what does Hydro use?

10 A. Well, for an external exposure, that
11 is, exposure to an external field we use
12 thermoluminescent dosimeters.

13 For internal doses we use bioassay
14 methods or other kinds of in vivo monitoring for
15 activity.

16 Q. Now, for external you use the
17 thermoluminescent dosimeters. Now, these do not
18 measure low-level beta radiation or low energy
19 scattered electron radiation or low energy gamma
20 radiation; do they?

21 A. No, the standard badge, as it's
22 called in a facility such as Hydro operates, has a
23 number of different chips, some of them are thick and
24 they are primarily responsive to penetrating radiation,
25 gamma rays; some of them are very thin and they are

1 responsive to beta radiation, and the purpose of those
2 is to estimate the dose to the surface of the skin
3 which is at risk from the use.

4 [12:15 p.m.]

5 Q. You are speaking of workers in Hydro,
6 but what about the general public, what form of
7 measurement is used for the general public?

8 A. We are not the only people that do
9 estimations of public doses. Certainly Health and
10 Welfare Canada, Ministry of Labour and others also do
11 this.

12 It's true that Noble gas exposures, for
13 example, are estimated using thermoluminescent
14 dosimeters. Our tritium doses are not estimated in
15 that way; they are estimated by analysis of samples and
16 by other methods.

17 I can't really speak for Health and
18 Welfare but I would presume they all use the same kind
19 of technology.

20 Q. Well, in Hydro's measurements, which
21 would have some effect on the general public, I am not
22 speaking of workers, do you measure this low level
23 radiation, the beta radiation, the low energy scattered
24 electron radiation, the low energy gamma radiation at
25 levels 30 to 50 kiloelectron volts, do you measure it

1 at that level?

2 A. I am afraid I can't give you the
3 technical details on the - let's call them TLDs - TLDs
4 that are used for environmental gamma monitoring, but
5 we can certainly get that for you, if you like.

6 But we were talking there about
7 monitoring for certain specific kinds that we know, we
8 know what the Noble gases are, we know what is emitted
9 from the station, we know what we are looking for, and
10 I believe that the monitoring system is set up that so
11 it will take care of all significant radiations.

12 Q. Well, is there any discussion of the
13 uncertainties surrounding the measurement of these
14 doses in Exhibit 507?

15 A. Well now, you are talking about the
16 measurement of doses and environmental monitoring --

17 Q. I am sorry, the measurement of the
18 radiation.

19 A. The measurement of the radiation is
20 only one step in the dose assignment. And I think it
21 is fair to say that in general there is much larger
22 uncertainty in the contributions to the dose from
23 environmental pathway modelling and so forth.

24 Q. I accept the uncertainties, I
25 appreciate that. But I am asking for a discussion in

1 this Exhibit 507 of some of the limitations of the
2 current methods of measurement. Is there any
3 discussion there?

4 A. I could look through for you, if you
5 like.

6 I think there is some indication of our
7 estimates of certain specific numbers like collective
8 dose per gigawatt year compared with other estimates
9 for other kinds of reactors.

10 But you are correct, we don't have a
11 specific chapter on uncertainty, and that was, I
12 believe, a deliberate attempt to keep this document
13 straightforward and reasonably compact.

14 Q. Well, uncertainty is in a sense the
15 name of this game as far as people are concerned. You
16 are dealing with various ranges of uncertainty, and if
17 you are going to make an assessment of what the true
18 costs are, you need to know, it seems to me, the range
19 of uncertainty with which those costs are calculated.

20 The point I am trying to make is that
21 there are numerous areas of uncertainty which have not
22 been fully explored or canvassed.

23 A. I think they have been dealt with
24 primarily through the method of referencing, for
25 example, ICRP documents. ICRP gives all sorts of

1 information about the uncertainty in its risk
2 estimates. We don't repeat that here. We just
3 reference the document.

4 Q. Let's go to back to ICRP. This time
5 I am going to refer to the paper of paper by Dr. Upton,
6 Exhibit 658. I would like to refer to page 26 of that
7 paper, and particularly table 20.

8 Now, I asked you about this the other
9 evening. I would like to explain the significance this
10 table, and in particular, explain the division by a
11 DREF of 2.0, and explain to me that the debate about
12 the use of that. And lastly, tell me whether or not
13 that debate was thoroughly canvassed in your materials?

14 A. Okay. Well, was your first question
15 about the DREF?

16 Q. The first question is just explain
17 this table.

18 A. Explain the table, okay.

19 As the title says, these are lifetime
20 cancer risk estimates in units of cancer deaths per 10
21 to the 4 population per sievert of exposure, and they
22 are based on UNSCEAR 1988 and the BEIR 5, 1990 report,
23 in comparison it with the ICRP 26, 1977 report.

24 I guess I should add that the ICRP 60,
25 1991 report, is very similar to the UNSCEAR/BEIR

1 numbers, although the analyses were to a large extent
2 independent.

3 They all are based on the same data, the
4 data -- certainly to the extent that they used the
5 Japanese survivor data, the data produced by the
6 Radiation Effects Research Foundation who prepared one
7 of the reports that we have talked about, No. 661.

8 So the new ICRP is similar to the
9 UNSCEAR/BEIR.

10 Now, as you can see, the risks for many
11 sites are now believed to be higher, and those are for
12 the reasons that I gave in my direct evidence.

13 The total is believed to be 5 times 10^{-2} to
14 the minus 2 per sievert as opposed to 1.25 times 10^{-2} to
15 the minus 2 per sievert in 1977. This would be for a
16 general age population.

17 We use a slightly lower number, 4 times
18 ten to the minus 2 per worker age distribution.

19 Now, that 5 times 10^{-2} to the minus, or 500
20 per 10^{-2} to the 4, includes a factor of reduction by a
21 factor of 2 for the solid cancers, and does not include
22 any extra factor for the leukaemia because it uses
23 already a linear quadratic response model which gives a
24 lower risk factor at low doses.

25 Q. Well, that division by 2, though, is

1 an issue which I gather is subject to some debate; is
2 that correct?

3 A. Let me read what ICRP 60 says about
4 that.

5 Q. Where are you quoting from, please?

6 A. I am quoting page 18, paragraph 74,
7 and this is in the section where they describe why they
8 have reached certain...

9 THE CHAIRMAN: Wait a minute now. Page
10 18 of what document, please?

11 DR. WHILLANS: This is ICRP, publication
12 60. And I don't believe it's an exhibit.

13 MR. M. CAMPBELL: I don't have that, I'm
14 sorry.

15 DR. WHILLANS: Is it an exhibit?
16 This was referenced in my direct
17 evidence.

18 MR. M. CAMPBELL: Q. Before you read
19 that section, could you read the paragraph on page 26
20 of that exhibit, Exhibit 658, which speaks in some
21 detail about the use of the dose rate effectiveness
22 factor.

23 DR. WHILLANS: A. Which paragraph is
24 that?

25 Q. The full paragraph below the table 20

1 on page 26.

2 A. Beginning with "although."

3 Q. That's correct.

4 A. "Although --

5 Q. I want you to just read it and
6 comment on it.

7 A. All right. Fine. Yes, I have read
8 it.

9 Q. Before you comment I would like to
10 refer you to the appendix of Exhibit 507, page AP 2-3.

11 A. I have it.

12 Q. And I am particularly interested in
13 the paragraph at the bottom which says the risks given
14 in table 2.2, that's another table elsewhere in that
15 document.

16 A. Yes.

17 Q. Now my question is: The issue of the
18 division of these numbers by two is indeed an issue
19 which is contested or at least there is some debate
20 about that, and my question is the extent to which that
21 debate has been adequately incorporated in the
22 appendix, which I gather is the most detailed part of
23 Exhibit 507.

24 A. Well, it's the most detailed part
25 with respect to these particular subjects.

1 Well, I agree with you that the use of a
2 factor of two is somewhat controversial and it is in
3 that range of uncertainty. And the risk estimates I
4 told you a few minutes ago, that's one of the major
5 contributors.

6 The situation is that we don't have
7 substantial evidence at low dose rate for the reasons
8 that Modan has given. And I think in previous
9 cross-examination we have been asked about some studies
10 which have been designed to test that, for example, the
11 large study recently published by the NRPB of U.K.
12 workers.

13 But I agree with you that there is
14 uncertainty about it.

15 The reason ICRP uses this is that there
16 is substantial evidence in other non-human species that
17 low dose and dose rate results in a lower affect.

18 I think it's probably important to point
19 out that, in my view anyway, the ICRP isn't looking to
20 reduce, or rather to increase dose limits, but it wants
21 to give recommendations based on the best evidence.

22 If you increase the accepted risk to
23 radiation, when you are judging cost benefits of
24 certain operations, you might well assume a greater
25 risk from some other sort of risk than you would from

1 the radiation if you are using biased results. And I
2 think ICRP's intent throughout is to give an unbiased
3 estimate.

4 Q. My point is that ICRP, some of the
5 materials that we have looked at, seems to put a
6 greater range of uncertainty around some of these
7 factors than Exhibit 507. That's my only point. I am
8 asking you to comment --

9 A. Where do we find that?

10 Q. I am trying to suggest that some of
11 the reservations expressed in the material I read to
12 you or we have examined is not fully reflected in 507,
13 so there is indeed a greater range of uncertainty than
14 the one would find in exhibit.

15 A. Well, perhaps you are right. Perhaps
16 for some purposes it would have been better to
17 emphasize uncertainties more.

18 But, again, I say the ICRP 60 is a
19 200-page document devoted only to that subject. We
20 weren't intending to reproduce that kind of detail in a
21 document which perspective on the risks of nuclear
22 power.

23 Q. Fair enough. It's a limitation of
24 the process that we have, I'm afraid.

25 A. That may be so.

1 Q. Look at my material. [Laughter]

2 Let's move on. I would like to talk
3 again -- back to Exhibit 507, I would like to talk
4 about the table on page 1.3, figure 1.1, which is the
5 table dealing with typical sources of radioactivity in
6 the environment. I have several questions about that.

7 I think the general thrust of that
8 figure, figure 1.1, is that the amount or quantity of
9 radioactivity emitted from the nuclear fuel cycle is
10 minimal or inconsequential compared to the total of
11 natural and artificial radioactivity; is that correct?

12 A. Well, I think that's one conclusion
13 you could take from the table. That's not the entire
14 purpose of the table.

15 Q. But the table does seem to suggest
16 that, and if you look at the bottom paragraph at page
17 1-2 of Exhibit 507, just to the left, the second
18 sentence:

19 The radiation dose compared with
20 radionuclide emissions from nuclear
21 stations should be compared with - and I
22 emphasize that - with the radiation dose
23 received by the public from other sources
24 and to the variability of this background
25 radiation.

1 Now you could compare it but you could
2 also add it on, could you not?

3 A. Certainly.

4 Q. So why was the word "compared with"
5 used as opposed to added on?

6 Surely that is a value judgment in
7 itself; is it not?

8 A. I think they are two distinctly
9 different activities.

10 The intent here was to say these are the
11 average doses to a member of the public, which we are
12 prepared to defend, result from nuclear power
13 generation, and radiation does not come only from power
14 generation, it comes from many other sources, and in
15 making decisions about carrying on activities or
16 changing activities, we should keep all these things in
17 perspective.

18 Now, I don't disagree that these doses
19 are in addition to --

20 Q. By saying perspective you are saying
21 it's a comparison.

22 A. Yes.

23 Q. But as you say, it's an addition--

24 A. That was the intent, yes.

25 Q. -- it's an addition, and there are

1 two distinct value decisions there.

2 A. I think there are many other ways in
3 which you can get a number which is much more accurate
4 than less than .1 millisieverts per year, and we have
5 provided some of those in our evidence.

6 I certainly agree that this is in
7 addition to the 3 millisieverts that result from
8 natural, and, yes, that is a reasonable conclusion.

9 Q. Well, I would also like to ask you
10 about the range for radon. In the table, figure 1.1,
11 the dose is given in millisieverts per annum as 2.0,
12 and in the last four or five lines of the bottom
13 paragraph at page 1.1, you show quite a range.

14 Am I correct that you show quite a range
15 for the short-lived decay products of radon-222?

16 A. Well, I guess I am not sure where
17 that range came from, but I certainly agree that
18 individual exposure to radon is highly variable. There
19 are some parts of the world and not -- well, for
20 example, in Cornwall, areas where there are high levels
21 of activity in the ground, have very high levels of
22 radon. And the uncertainty also results because of
23 different conditions of housing. It is a very
24 uncertain number, that's true.

25 Q. Well, is the number which you have

1 given in figure 1.1, where is that in the range of
2 quantities?

3 The bracket in the fourth line at the
4 bottom of the paragraph at page 1.2 of the exhibit
5 reads from .4 millisieverts per annum to 20
6 millisieverts per annum, and then minus 80 per cent to
7 plus 900 per cent?

8 A. That's right.

9 Q. Why was the figure 2 chosen for that
10 particular -- for figure 1.1?

11 A. Well, the figure 2 is that
12 recommended by NCRP which has estimated radon exposures
13 for Canada and the United States.

14 Q. Is this table, then, the title is
15 Average Annual Effective Dose Equivalent for Ionizing
16 Radiations to a Member of the Public. Is this
17 Canada-wide or North America that we are averaging this
18 for?

19 A. There is some Canadian-specific data.
20 But in general there is more information averaged over
21 North America, but they are not large differences. For
22 example, NCRP report 94 that I referred to, breaks it
23 into Canadian and American, you can see that they are
24 fairly similar.

25 Some are very similar. Of course

1 the internal doses from potassium 40 don't vary by
2 national boundary, but because of geological conditions
3 are different, radon is higher in some parts of the
4 world than others.

5 Q. Another implication that one draws
6 from this is that the addition, the radiation added by
7 the nuclear fuel cycle is minor compared to say radon,
8 for example, but radon itself is a very dangerous
9 element, is it not, a very dangerous substance?

10 A. Exposure to radon-222 almost
11 certainly has significant health effects, yes.

12 Q. And the document I would like to
13 refer to is the extract from the Lancet, Epidemiology:
14 Radon as a Causative Factor in Induction of Myeloid
15 Leukaemia and Other Cancers. And again --

16 THE CHAIRMAN: I am sorry, what number is
17 that?

18 MR. M. CAMPBELL: I believe that's
19 Exhibit 656.

20 Q. The paragraph which I am really
21 concerned with is just the abstract right at the top on
22 the left-hand column.

23 There is significant correlation of radon
24 exposure in the home, so radon itself is not a benign
25 substance; is that correct?

1 DR. WHILLANS: A. Yes.

2 Q. Now, exposure in the home is
3 generated from what, exposure or radiation from
4 construction materials, that sort of thing, used in
5 home construction?

6 A. Well, this is a very active area of
7 research as you can imagine, because it is a
8 significant contributor to average radiation exposure.
9 And the significance of it has really only been
10 recognized in the last 10 years.

11 So because it's an active area of
12 research, views about where it primarily arises have
13 changed.

14 I think the consensus now would be that
15 for most conditions the main source is the soil
16 underneath the house. Some small amounts come in
17 natural gas, they come in water, and they come from
18 building materials, but the main source is usually
19 penetration of the house from below.

20 [12:35 p.m.]

21 Q. Do you have any information - I may
22 point you to an exhibit in a moment - on the proportion
23 of radon emitted from either industrial uses or from
24 technological enhancements, such as construction or use
25 of materials, rock and brick and so on, and I think I

1 should, in fairness, point you to UNSCEAR Exhibit 653,
2 and the extract which I photocopied.

3 There is a reference to several pages in
4 that exhibit. The reference is to paragraph 1.41 where
5 it says:

6 Industrial activities that release
7 materials with enhanced concentration
8 of naturally occurring radon do not
9 significantly --

10 A. I'm sorry, paragraph 1.41 --

11 Q. Yes.

12 A. Of 653?

13 Q. Whoops. Excuse me, just a moment.

14 THE CHAIRMAN: You are right.

15 MS. PATTERSON: Yes, you are right.

16 MR. M. CAMPBELL: Is that right?

17 THE CHAIRMAN: Yes.

18 DR. WHILLANS: Okay, yes. Beginning
19 table 4?

20 MR. M. CAMPBELL: Q. That's right. I
21 just want you to understand, I want to make sure we are
22 on the same wavelength here.

23 But I'm curious about any information
24 which you have which would either confirm, or can tell
25 us what significant means in this context.

1 A. Well, I think it was Mr. Greenspoon
2 who was cross-examining when I referred to NCRP Report
3 No. 78 which is called Evaluation of Occupational and
4 Environmental Exposures to radon and radon daughters in
5 the United States.

6 And on page 12 of that document, table
7 3.1, entitled: Sources of Global Atmospheric
8 Radon-222, they list nine significant sources. The
9 first is emanation from soil at a rate of 2 times 10 to
10 the 9 curies per year, and then there are a number of
11 others, fifth is uranium tailings piles at 2 times 10
12 to the 6 curies per year and there are others.

13 By far the largest source is emanation
14 from the soil and the tailings piles, for example, are
15 on a global average about one one thousandth of that.

16 Q. So the UNSCEAR document which I have
17 just cited to you is basically correct, in your
18 estimation?

19 A. I think so.

20 Q. So my point now, I return to my
21 point; and, that is, radon is itself a dangerous
22 substance has in certain circumstances a malign effect
23 on human kind and one could say that one is adding to
24 that from the fallout or the radioactivity from the
25 nuclear fuel cycle; is that correct, one is adding

1 to --

2 A. Well, are you suggesting, or perhaps
3 you are restating what I said, that to the extent that
4 uranium tailings contribute to radon-222 about .1 per
5 cent, that is in addition to other sources.

6 Q. Okay.

7 A. Is that your statement, because--

8 Q. I'm just saying one is adding on.

9 A. --those tailings in fact are
10 dangerous only by their availability, that uranium is
11 natural.

12 Q. Well, they may be available to a
13 number of people if they live in the area and so on.

14 A. Yes.

15 Q. But my point is that you are adding
16 on to an already dangerous substance, that is really my
17 point.

18 A. To the extent of one part in a
19 thousand.

20 Q. Yes.

21 A. Yes.

22 Q. Okay. Now, secondly, or my next
23 point is having to do with figure 1.1 is that this is
24 an average annual dose to the public. Now, in this
25 sense a member --

1 THE CHAIRMAN: 1.1 of 507?

2 MR. CAMPBELL: 1.1 of 507, I'm sorry.

3 THE CHAIRMAN: By the way, that page 78,
4 table 3.1, what was that document?

5 DR. WHILLANS: No, it was NCRP Report No.
6 78 and I read the title.

7 THE CHAIRMAN: I'm sorry.

8 DR. WHILLANS: It was page 12, table 3.1.

9 THE CHAIRMAN: Has that document been
10 marked in any way?

11 MS. HARVIE: No, Mr. Chairman.

12 DR. WHILLANS: No. I should say you may
13 have noticed that I refer to the NCRP series of reports
14 fairly frequently.

15 The NCRP is a non-industrial
16 non-governmental, I guess, body in the U.S. which
17 produces a series of reports to do with radiation and I
18 do rely on them. The carbon document was similar.

19 THE CHAIRMAN: My recollection, though it
20 is far from perfect, is that you gave that same kind of
21 evidence in reply to a question from Mr. Greenspoon.

22 DR. WHILLANS: Yes.

23 THE CHAIRMAN: And I didn't make a note
24 at the time of the actual document that you were
25 referring to.

1 DR. WHILLANS: Oh, okay.

2 MS. HARVIE: If it would be helpful, Mr.
3 Chairman, we can perhaps get additional copies of this
4 and file it.

5 MR. M. CAMPBELL: I have completed my
6 questions already on radon, as far as I am concerned.

7 THE CHAIRMAN: Just if it's going to be
8 useful. If it's not, I don't feel strongly about it
9 one way or the other.

10 MS. HARVIE: Well, if nothing else,
11 perhaps we can just photocopy the table and introduce
12 that.

13 I understand we may have some difficulty
14 in getting some additional copies from the publishers.

15 THE CHAIRMAN: I don't know whether Mr.
16 Greenspoon like to see a copy of it, he's here today.

17 MR. GREENSPOON: The table would be fine.

18 THE CHAIRMAN: Why don't we get the
19 table.

20 MS. HARVIE: All right, okay.

21 MR. M. CAMPBELL: Q. May I return then
22 to Exhibit 507 page 1.3 figure 1.1. When you take an
23 average annual effective dose, when you take an
24 average, we are not certain whether this is Canada,
25 North America; is that correct, we don't know that?

1 DR. WHILLANS: A. Well, I'm certain
2 about some of the categories, and --

3 Q. Well, isn't there immense difference?

4 A. No. I think I said a few moments ago
5 for the internal dose, which is due to internal
6 potassium 40 mainly, there would be no difference
7 essentially between countries, there would be some
8 small differences among individuals.

9 But radon is specific to the geological
10 area you are considering and so there are some
11 differences between some areas of the United States and
12 some areas of Canada, but also between areas within
13 each of those countries. So I think this is a fair
14 representation for Canada as well.

15 Q. But if you are speaking dose to a
16 member of the public you are taking a number of people;
17 are you not, and if you include the United States you
18 are talking 250 million people in a relatively small
19 geographic area?

20 A. This is to a member. This is divided
21 by the number of people that are involved.

22 Q. But if you take Canada you are
23 talking 25 million people in a much larger area and
24 radon emanating from the soil, one would think that the
25 rate would be higher; is that -- am I off?

1 A. Ah, but you see, we explored this
2 also in a previous cross-examination.

3 Q. I'm sorry if I -- I didn't intend to
4 review what you --

5 A. No, no. Certainly my evidence was
6 that radon, because of its short lifetime, is limited
7 to exposing people who live very locally to its
8 emanation from the soil, whether it's from a tailings
9 pile or from under a house.

10 So if there's a large source of radon in
11 Alberta, that is not going to expose members of the
12 population in Ontario. So I think the problem with
13 national averaging isn't a problem.

14 Q. But these numbers apply to Ontario?

15 A. Generally yes.

16 Q. The citizens of Ontario?

17 A. Generally yes, but there certainly
18 would be variations in that 2 millisieverts between one
19 part of Ontario and another.

20 Q. Fair enough. Now, when you take this
21 over a period of a year, you average out what might be
22 called surges in the level of radioactivity received by
23 a member of the public; is that correct?

24 A. Yes.

25 Q. So that if one happened to walk by a

1 nuclear power plant during an unusually high emission
2 of radioactive materials one would get, in a short
3 period of time, a much greater --

4 A. Well, I think this really -- this is
5 figure 1.1, it's an introductory figure for
6 perspective. I think this isn't really where you ought
7 to turn for specific information about exposures of the
8 public from nuclear power generation activities.

9 This is a number taken out of a similar
10 NCRP document which applies generally to nuclear power.

11 Q. But on the face of it, this document
12 would not pick up a surge or a sudden --

13 A. Well, but what I am saying is that we
14 publish in our annual summary an assessment, which has
15 been filed for many years, the dose to the most exposed
16 member of the public and that would take into account
17 those kind of events.

18 Q. Well, one other brief point on this
19 table, but I want to return and canvas with you the
20 concept of effective dose equivalent later on, but an
21 individual worker - and this is not a person who would
22 be included in this table - a worker would not be
23 included in this table; is that correct?

24 A. Only when he's not at work.

25 Q. I see. But a worker could receive

perhaps up to 50 millisieverts in a year; could they
not?

A. The legal limit in Canada is now
that, yes.

Q. So that's a conceivable number that
one could add in, if you were including workers in this
and worker exposure?

A. Well, I think we are distinguishing
between members of the public and workers when they are
not members of the public.

Q. All right.

A. Certainly there's no attempt to hide
the fact that this does not include occupational doses.

Q. I will leave figure 1.1 and just go
down to the next paragraph on 1.3 which begins with the
words:

Certain levels of ionizing radiation
can disrupt molecules.

Really we mean all levels; is that
correct, or any level?

A. I circled certain levels in my own
notes and a question mark.

Q. What was the answer to your own
question?

A. I'm not sure what that meant, certain

1 levels.

2 Q. I see.

3 A. Appendix 2 --

4 Q. Well, you know how I feel quite
5 frankly.

6 A. Yes.

7 Q. The certain, surely you mean any
8 level?

9 A. Any level can disrupt molecules, yes.
10 If it's absorbed by the molecule it can certainly
11 disrupt it, yes.

12 Q. Well, the next sentence:

13 The various affects and so on are
14 described in Appendix 2 -- and we'll get
15 to Appendix 2 later on.

16 And then you go on to say:

17 These hazards and their perception
18 by workers and the public are important
19 issues associated with nuclear
20 generation.

21 Now, I realize this is an introductory
22 chapter and so on, but it strikes me that perception is
23 essentially a marketing or a sell the product term; is
24 it not, and no particular --

25 A. Not in my terms, no.

1 Q. Let me ask you this question then.

2 In the first part of chapter 1 at page 1.1, first
3 paragraph, you speak about conservatisms in ICRP risk
4 estimates, and by conservatisms what would you mean;
5 you are erring on the side of what, overestimating the
6 risks or underestimating the risks?

7 A. Overestimating.

8 Q. Well, how does that square with the
9 perception if you are overestimating, does it not give
10 people the perception that the risk it is greater than
11 it actually is. Do you not have a conflict here?

12 A. Well, on page 1.1 we are talking
13 about -- the statement is, due to conservatisms in the
14 ICRP risk estimates and the author was referring to
15 some evidence that the numbers at low doses and dose
16 rates may be higher than the actual estimates.

17 I don't really see the conflict with your
18 question about perception. I think perhaps I have a
19 different idea of perception of risk than you are
20 suggesting.

21 Q. Can you explain that, please?

22 A. I think we are simply making a
23 distinction between what we believe is the scientific
24 evidence and how that evidence is sometimes perceived
25 by workers or the public and, in some cases, we believe

1 that the perception is different from the scientific
2 evidence and, in some cases, we think it's important
3 that that should be corrected.

4 Q. Fair enough. I would now like to --
5 I think I have finished with chapter 1. I don't
6 believe I have very much on chapter 2, perhaps I could
7 just put one or two questions on chapter 2 of Exhibit
8 507.

9 At page 2.1, the third paragraph down we
10 speak of the tritium recovery facilities and the
11 purpose is to reduce worker and public exposure to
12 tritium to minimum levels.

13 Is there not an emission of tritium at
14 the recovery facility; is tritium not emitted?

15 A. From time to time there have been
16 emissions of tritium from the TRF, yes.

17 Q. And it's not the purpose, but the
18 effect surely is that tritium is indeed released; is it
19 not?

20 A. Well, I think generally speaking none
21 of these emissions is deliberate and they are
22 controlled within the derived emission limits that are
23 set for the facility by the Atomic Energy Control
24 Board.

25 Q. And you are also transporting

1 tritium; are you not, from Bruce to Darlington and so
2 on; is that correct?

3 A. Yes.

4 Q. Is there any risk of loss or emission
5 of tritium during the transportation phase?

6 A. There is a risk of an accident and
7 again that risk is estimated and controlled.

8 Q. I see. That's all I have on chapter
9 2. Chapter 3, if I may. Page 3.1 of Exhibit 507 under
10 the heading Fuel Supply, the third paragraph:

11 Ore from Ontario mines contains about
12 .1 per cent uranium and is mined
13 underground. The Saskatchewan ore
14 contains 2 to 40 per cent uranium...and
15 so on...and is mined in open pits.

16 The other 99.9 per cent of the ore from
17 Ontario mines, do they also contain radioactive
18 materials like radium, Thorium, lead, bismuth,
19 polonium?

20 A. Certainly some of the ore is
21 radioactive, yes.

22 Q. And usually that is left aboveground
23 in the tailings; is that correct?

24 A. Well, if you want details perhaps I
25 should ask Mr. Johansen if he would like to help.

1 Q. Let's just -- this is normally
2 aboveground, I'm just asking that question. I'm not
3 asking for quantification.

4 A. There is radioactivity in the
5 tailings, yes.

6 Q. And so this is bioavailable which, as
7 a result of mining, it would not otherwise be?

8 A. Well, if you say bioavailable,
9 perhaps I will turn it over to Mr. Johansen.

10 MR. JOHANSEN: A. I guess we spent some
11 time with --

12 Q. Again, I don't really want to
13 belabour this. I gather you have had a fair amount of
14 questioning on this area, I just wanted to -- for the
15 sequence of my question.

16 A. I can simply say that the tailings
17 are contained within a system of natural and
18 constructed dams or barriers and there is treatment of
19 the effluent to settle out the solids and radium prior
20 to discharge to the water body.

21 Q. I gather much of that effluent would
22 end up in the Serpent River; is that correct?

23 A. That is the main --

24 Q. Do you have any information on
25 whether or not the Serpent River is contaminated above

1 regulations. Do you have any information on that?

2 A. We don't have a lot of information on
3 that. There was some information in the Porter report,
4 Volume 6, I believe there was a table that indicated at
5 the time that that report was written in the late 70s,
6 culminating in the final report 1980, some indication
7 that in some cases there was some exceedance above the
8 water quality criteria at that time.

9 It's my general understanding that the
10 improvements in the effluent treatment methods at least
11 the active tailings areas up there has led to
12 improvements in the water quality of Serpent River, but
13 I don't have any hard data that I can point to that
14 exists conveniently.

15 Q. Fair enough. I would like to turn
16 over to page 3.9 of this exhibit, and the second
17 paragraph, during normal operation of a CANDU nuclear
18 station.

19 I wanted to ask you Dr. Whillans about
20 TLDs we were referring to earlier. Do they register
21 all of the emissions which are listed here?

22 DR. WHILLANS: A. Listed in the second
23 paragraph?

24 Q. In that paragraph, waterborne
25 radioactive effluents--

1 A. No.

2 Q. --tritium, gross beta gamma,
3 Carbon-14?

4 A. No, no, they are not.

5 Q. Those are not?

6 A. No. Only external radiation.

7 Q. So that is not caught by that?

8 A. No. Tritium for example is sampled
9 in an entirely different way.

10 Q. I see. I have a number of questions
11 on page 3.10 having to do with the standards, but I
12 would like to defer that to later on when I will be
13 referring to some of the other issues surrounding
14 standards.

15 And similarly at page 3.14, I will put
16 some questions respecting hydrogen sulphide later on in
17 the cross-examination.

18 I wanted to put a question at page 3.15,
19 at the very bottom of the page, there's reference to
20 typical low and intermediate level wastes including
21 contaminated rags, mops, filters, ion exchange resins,
22 used equipment being transported to Bruce for
23 centralized volume reduction and storage at the
24 radioactive waste operation site.

25 And the materials, I gather, are

1 incinerated; is that correct? Some are compacted it
2 says here and some are incinerated; is that correct?

3 MR. JOHANSEN: A. If we are talking
4 about the very low level so-called incinerable wastes,
5 mostly paper and that sort of thing. It would be
6 mostly paper.

7 Q. Well, would radioactive -- or
8 radio-contaminated rags, mops, filters be incinerated?

9 A. No, not all of that. Only the very
10 low level or lowest level of the type 1 could be
11 incinerated.

12 Q. Well, do you have any information on
13 the releases of radioactivity to the air following
14 incineration?

15 A. Yes, I could give you some
16 information on that, if you would like.

17 Q. And you would agree that there would
18 be a waste deposit in the form of ash at the end of
19 this incineration. I take it there would be more
20 radioactive material in that at the end of the
21 incineration process; is that right?

22 [12:55 p.m.]

23 A. In the ash, yes.

24 Perhaps a short answer to your initial
25 question is that the emissions from the incinerator,

1 indeed from the entire waste volume reduction facility,
2 are included in the emissions which I testified about
3 in my direct evidence. And there are some charts which
4 I presented at that time in Exhibit 519 for the Bruce
5 site including those emissions from the incinerator --

6 Q. If it's been dealt with elsewhere I
7 won't belabour the point.

8 Do you have any information on any other
9 forms of emissions that are non-radioactive, for
10 example, carbon dioxide? Is that included?

11 A. From the incinerator again?

12 Q. Yes.

13 A. Yes. I don't have them at the
14 fingertips but there would be conventional pollutants
15 emitted as well.

16 Q. And can there be an increased adverse
17 effect from the combination of radioactive material
18 being emitted together with these other forms of waste
19 products such as carbon dioxide, any information on the
20 synergistic effect of this?

21 A. Positive or negative synergistic
22 effects?

23 Q. Yes.

24 A. Certainly the issue of synergism, one
25 way or the other, has been considered from time to

1 time. I'm not aware that there is a concern amongst
2 the regulators, the AECB or the Ministry of the
3 Environment in this particular case with regards to
4 synergistic effects.

5 DR. WHILLANS: A. Certainly radiation
6 does interact with some materials in causing health
7 effects, but I wouldn't think carbon dioxide is one. I
8 know of no evidence of that anyway.

9 Q. Very well. Just my last question on
10 chapter 3, there is reference to accident conditions.
11 Later my cross-examination I want to speak about the
12 emergency planning, I may want to return to that.

13 And the very last page of chapter 3,
14 3.18, the first top paragraph:

15 All radioactive waste including active
16 concrete will be packaged in approved
17 containers and transported to an
18 engineered disposal facility assumed to
19 be off-site.

20 I take it there is no such facility in
21 existence at this time; is this correct?

22 MR. JOHANSEN: A. There is no facility
23 for decommissioning waste disposal as yet.

24 Q. And what is the time frame for
25 preparation of such a facility?

1 A. This would be the same facility which
2 would accommodate other so-called low and intermediate
3 level wastes, and Ontario Hydro is currently, as I have
4 indicated in previous testimony, Ontario Hydro is
5 currently updating its plan. And I can say, I have
6 said previously, that the target date for planning
7 purposes at least for a disposal facility to be
8 in-service is the year 2015.

9 MR. M. CAMPBELL: That completes my
10 questions on chapter 3. I think before I start on 4,
11 we might, looking at the time, have our lunch break.

12 THE CHAIRMAN: All right. We are
13 adjourned until 2:30.

14 THE REGISTRAR: Please come to order.
15 This hearing will adjourn until 2:30.

16 ---Luncheon recess at 1:00 p.m.

17 ---On resuming at 2:35 p.m.

18 THE REGISTRAR: Please come to order.
19 This hearing is again in session. Please be seated.

20 THE CHAIRMAN: Ms. Harvie?

21 MS. HARVIE: Yes, Mr. Chairman. This
22 morning a reference was made to a table in the NCRP
23 report No. 78 and I promised at the time to file a copy
24 of the table which I am doing now, I have given eight
25 copies to Mr. Lucas and it should be marked as an

1 exhibit, please.

2 THE CHAIRMAN: Exhibit number, please.

3 THE REGISTRAR: 666.

4 ---EXHIBIT NO. 666: NCRP Report No. 78.
5 Recommendation of the National Council on
6 Radiation Protection and Measurements.

6 MS. HARVIE: Thank you.

7 There are additional copies on the side
8 table and I have placed one at Mr. Greenspoon's spot.
9 If he's not here this afternoon, I will send it to him.

10 THE CHAIRMAN: Thank you.

11 MR. M. CAMPBELL: I thought, Mr.
12 Chairman, just to complete a tiny matter which I missed
13 in canvassing figure 1.1, I thought it would be
14 appropriate to refer very briefly to Interrogatory No.
15 9.22.98, Exhibit 520.145, which has to do the medical
16 radiation level. That should have been referred to in
17 connection with the material canvassed in figure 1.1.
18 I don't think anything turns on it, it is just a
19 statement in which there is wide variation in
20 individual exposures.

21 Unless Dr. Whillans has any comment on
22 that, I don't think we need to belabour it.

23 THE CHAIRMAN: You want to identify that
24 the answer to that interrogatory is part of the record.

25 MR. M. CAMPBELL: That's correct, yes, in

1 connection with figure 1.1.

2 THE CHAIRMAN: Is that all right, Dr.
3 Whillans.

4 DR. WHILLANS: Yes, I agree.

5 MR. M. CAMPBELL: Q. And the other
6 matter I wanted to speak to in connection with chapter
7 3, a matter which I didn't quite put in at the right
8 spot.

9 I believe that I can refer to Exhibit
10 654, which is the list of particulates and gross beta
11 gamma emissions, which should also be added to --
12 should be included among the emissions from the nuclear
13 fuel cycle, lifecycle; is that correct, Dr. Whillans?

14 DR. WHILLANS: A. Sorry, could you refer
15 me to the page?

16 Q. Exhibit 654.

17 A. Yes, I have that, and you said some
18 part of chapter 3.

19 Q. I am not sure exactly where in
20 chapter 3 it should come, or whether it might be
21 properly in chapter 4.

22 Would it be more properly referred to at
23 chapter 4, page 14, the figure 4.4?

24 A. That figure certainly refers to the
25 radioactive emissions from the stations, yes.

1 Q. Okay, I will refer to it.

2 THE CHAIRMAN: I'm sorry, I am not
3 quite...

4 DR. WHILLANS: Figure 3.8 in chapter 3
5 also refers to the subject. It shows pictorially the
6 radionuclide pathways in the environmental and this
7 refers to one of those. That's on page 313.

8 THE CHAIRMAN: What was the page?

9 MR. M. CAMPBELL: I am sorry. I regret
10 that I have confused you, Mr. Chairman. But Exhibit
11 654 is a list of radionuclides, airborne particulates
12 and gross beta gamma, and I wanted to insert them for
13 the record I believe in Exhibit 3 as some of the
14 emissions which are generated from nuclear fuel cycle,
15 and we thought that this could be listed in connection
16 with figure 3.8 on page 3.13. Just to show some of the
17 particulates and other items which are emitted; is
18 that correct, Dr. Whillans?

19 DR. WHILLANS: A. Yes. Your list has
20 both airborne and liquid activity.

21 Q. All right. Okay.

22 DR. CONNELL: If we are going to make any
23 use of this, I would need to have the tabulation
24 elucidated for me. I don't know what the units are.
25 Curies per week, but it doesn't make clear which column

1 is curies per week.

2 DR. WHILLANS: I think all the numbers
3 are curies per week except for the isotope number.

4 So for example, in the first page, the
5 first entry happens to be chromium-51. The DEL in
6 curies per week based on whole body exposure for an
7 adult would be 7,740 and it would be 2,500 for skin,
8 and so forth.

9 I think what he has done is listed the
10 whole lot. As he says in the footnote at the top:

11 The value used for the DEL is the most
12 restrictive (the value that is
13 underlined).

14 In that case, strontium-90, dose to bone
15 surfaces was the most restrictive and that was
16 underlined.

17 MR. M. CAMPBELL: Q. The question I wish
18 to put had to do with strontium-90 and I was going to
19 ask Dr. Whillans for his comments on the effects of
20 strontium-90 in these quantities on both adults and
21 infants.

22 DR. WHILLANS: A. At these quantities,
23 meaning at the DEL?

24 Q. Yes.

25 A. Well, the DEL is, as you know, is set

1 so that the most exposed members of the public will
2 receive, may receive, the dose limit, and the dose
3 limit could either be a whole body dose limit, or in
4 the case of some nuclides could be based on dose to a
5 single organ. These are deterministic limits.

6 So in the case of strontium, as you can
7 see, the most restrictive DEL, the lowest number of
8 curies per week, is for dose to bone surfaces, and in
9 that case it was 1987, that would mean a .5 sievert
10 dose to bone surfaces. This would be the committed
11 dose as a result of intake and the dose could occur
12 over the lifetime of the individual.

13 Q. Now, the particulates noted in that
14 exhibit, have they been included in your estimates of
15 dose later on in this report?

16 A. Yes. The estimates, for example,
17 that are based on our annual summary which gives
18 critical groups and collective doses include
19 particulate doses as well.

20 Now, I guess I thought the point you were
21 making here was that there is a large number of
22 particulates, and one is selected for calculation
23 purposes, it's the most restrictive. And it can also
24 be the case that if doses were very low we might assume
25 that a proto-particulate emission was strontium and of

1 course that would be conservative if it contained some
2 of these other less restrictive things.

3 Q. We will return to that later. I
4 would like to focus on chapter 4.

5 DR. CONNELL: Excuse me, Mr. Campbell,
6 just before you move on.

7 This concerns the whole Darlington plant?

8 DR. WHILLANS: Yes. I think this is a
9 response to the project officer, the AECB project
10 officer at Darlington who had asked some questions
11 about the Darlington derived emission limits.

12 DR. CONNELL: Right. So if the emission
13 of strontium-90 did not exceed 2.3 curies per week,
14 then the most exposed individual would have the risk of
15 exposure of the bone surface limited to whatever --

16 DR. WHILLANS: The limit at that time
17 would be .5 sieverts.

18 DR. CONNELL: .5 sieverts.

19 DR. WHILLANS: I must say, I haven't
20 checked these numbers myself, but that's what this
21 says, yes.

22 DR. CONNELL: Okay. Thank you.

23 MR. M. CAMPBELL: Q. This is perhaps a
24 smaller point, but on page 4.5 of chapter 4 there is
25 reference to coarse fish, I don't want to spend much

1 time on it, but I take it coarse fish are defined as
2 those having no sport or commercial value, but I ask
3 whether they are other part of the food chain for other
4 fish which are potentially of commercial value.

5 A. I hope Mr. Johansen could answer
6 that.

7 MR. JOHANSEN: A. Well, I'm not a
8 biologist, but from my association with biologists in
9 the department, I would interpret that to refer to fish
10 other than sport fish or fish of commercial value, yes,
11 and we are perhaps talking for example, alewives and
12 the like.

13 Q. So, in absolute terms how many
14 tonnes, I guess, of fish are destroyed in the course of
15 the operation?

16 A. I don't have numbers off the top of
17 my head, unless there was some information in here.
18 However, I could point you to interrogatory information
19 that is available.

20 Q. I won't press it. I am sure other
21 parties will take a greater interest in that, if they
22 haven't already.

23 I am more interested on page 4.7, a
24 little more discussion on the monitoring of various
25 non-radioactive chemicals. In the second paragraph

1 which begins, small leaks of hydrogen sulphide, there
2 is reference to the concentrations:

3 The Ministry of the Environment
4 monitors non-radioactive chemical and
5 continues to use MPCs.

6 Are you familiar with those initials?

7 A. I am not sure I have quite caught up
8 with you.

9 Q. MOE has set a half hour limit of 20
10 parts per billion for hydrogen sulphide concentrations.

11 A. Yes.

12 Q. Is that on the basis of derived
13 emission limits, or is that on the basis of maximum
14 permissible concentration?

15 A. On the basis of maximum ground level
16 concentrations. They have two standards, one is for
17 ambient air quality and the other is for so-called
18 point of impingement, which ground level concentration
19 is one example of that.

20 Q. Well, of the two standards, MPC or
21 DEL, which is the more lenient and which is used by
22 AECB with respect to radionuclide emissions?

23 DR. WHILLANS: A. Since we had some
24 discussion earlier, maybe I understand what you are
25 saying.

1 Q. Yes, perhaps Dr. Whillans could speak
2 to that.

3 A. I think the concept of DELs and MPCs
4 is more or less restricted to radioactive emissions.

5 Those particular terms, to my knowledge,
6 aren't used by the Ministry of the Environment.

7 They are based on the idea that it's the
8 integrated activity emitted over a period, a week or a
9 year, which is important. Whereas in some of these
10 chemical - Mr. Johansen can correct me if I am wrong -
11 these chemical examples, it might be the instantaneous
12 concentration that was more important.

13 MR. JOHANSEN: A. Yes, I can confirm
14 that.

15 The Ministry of the Environment has two
16 sets of limits which they have applied to our operation
17 at the heavy water plant. There is a concentration
18 limit, the air quality criteria and the impingement
19 criteria which I have referred to for airborne
20 emissions, and there is also a site-specific rate limit
21 for waterborne emissions.

22 Q. And which is the more stringent? Are
23 they pretty stringent in their own particular --

24 A. I think they are both set so that
25 they protect the most sensitive species of the

1 environment, or humans as the case may be.

2 In the case of effluent to water I
3 believe the limit is based on toxicity to fish.

4 Q. Fair enough.

5 Let me move over to page 4-14, figure
6 4.4. This we discussed earlier, Dr. Whillans. Perhaps
7 you could correct the numbers on the record so the
8 Board is...

9 DR. WHILLANS: A. Well, I think Mr.
10 Johansen has the numbers.

11 Q. I'm sorry.

12 A. There is some corrections to table
13 4.4.

14 Q. We spoke about this earlier, if you
15 could perhaps correct those for the Board?

16 MR. JOHANSEN: A. Yes, I am advised by
17 the coordinating author, I think I referred to her as
18 the coordinating author previously in testimony, that
19 for the figure in the emissions to water category --

20 Q. Tritium, yes.

21 A. Tritium should have -- the number is
22 correct. However, it should be times 10 to the power
23 of 3.

24 Gross beta, again the number indicated
25 here is correct but it should be to the power 10, or it

1 should have 10 to the minus 2 added beside it.

2 Q. I see. Now, when you say routine
3 radioactive emissions for station operations average
4 1985/89, what exactly is the average? What are you
5 averaging there?

6 A. I understand that what they have done
7 is they have taken the average emissions from each of
8 the existing nuclear stations for those years, and
9 averaged them out and normalized them to a gigawatt
10 annum energy basis.

11 Q. Can you give me any estimation of
12 what this is in absolute terms for any given year of
13 operation? Is that a very complicated --

14 A. Well, again in Exhibit 519, which is
15 the overheads from our direct evidence, we presented
16 several charts that gave emission values in absolute
17 terms, and the same charts compare those emission
18 values to the derived emission limits. And I used
19 those charts to make the point that in every case, for
20 all of the radionuclide groups, the emissions are less
21 than 1 per cent of the regulatory emission limit.

22 Q. Do you have those in absolute terms?

23 A. Yes, they are presented in Exhibit
24 519, pages 46 through 49.

25 [2:55 p.m.]

1 And there are others for all of the other
2 Ontario Hydro facilities, nuclear facilities, which I
3 didn't happen to select for this package.

4 Q. Fair enough. Is Carbon-14 mentioned
5 anywhere?

6 A. Yes.

7 Q. Where is that included?

8 A. I believe we did special sampling on
9 Carbon-14 for Pickering. Let me just check that that
10 was included in these charts.

11 It doesn't happen to be in these charts,
12 but if that information is required I believe, in fact,
13 it was discussed in the annual radiological assessment
14 reports.

15 Q. Okay. I understand a number of
16 parties have spent some time on this chapter, I'm
17 trying not to go over ground which has been canvassed.

18 DR. WHILLANS: A. For example, in
19 Exhibit 520.15 which was our 1990 annual summary
20 assessment of environmental radiological data,
21 Carbon-14 is measured for Darlington, for Pickering,
22 for Bruce in milk, and I think it's measured in other
23 areas as well.

24 But there are detailed numbers, absolute
25 numbers the emissions from each station for that year

1 for Carbon-14 and for other nuclides in various
2 pathways.

3 Q. I would like now to move over to
4 chapter 5, if I may, which is the impact on human
5 health. And what I would like to do is start with the
6 concept of dose, if I may, if that is appropriate here
7 and, in particular, the concept referred to in figure
8 1.1, effective dose equivalent.

9 It might be useful to refer to the
10 UNSCEAR document, Exhibit 653, in particular paragraphs
11 37 through 41.

12 I gather that the concept of effective
13 dose equivalent, particularly as set out in paragraph
14 38, has some limitations, and I ask, Dr. Whillans,
15 perhaps if you could go over some of those limitations
16 or exclusions.

17 A. Well, I'm sorry, I don't remember you
18 asking me about limitations, I thought I was looking
19 for an explanation of the concept.

20 Q. Well, explain the concept then.

21 A. Well, as it says in these paragraphs
22 of UNSCEAR, the concept was used in the ICRP 1977
23 recommendations to provide an integrated value of risk
24 for exposures which don't uniformly irradiate the whole
25 body.

1 In previous ICRP recommendations, for
2 example, the concept of critical organs was used and
3 that basically said that there would be a dose limit
4 for the thyroid and then there would be a separate dose
5 limit for bone surfaces or for lungs and so forth, and
6 you could have them independently.

7 The idea of effective dose equivalent was
8 to weight an exposure, for example, to thyroid and add
9 it to a weighted exposure of lung and so forth for all
10 the major radiosensitive organs of the body and the sum
11 of these weighted doses would be the effective dose
12 equivalent.

13 And the weighting factors are derived,
14 they are published in ICRP but they are derived from
15 the relative radiosensitivity for the induction of
16 stochastic damage cancers or genetic effects.

17 Q. At page 7-3 of Exhibit 507 you have
18 defined effective dose equivalent.

19 A. Yes. That's a fairly brief --

20 Q. Fairly cursory.

21 A. Yeah.

22 Q. But my interest is in the weighting
23 factor specified by the ICRP.

24 A. Yes.

25 Q. Now, that weighting factor is, as you

1 mentioned, published, but my question has to do with
2 the range of uncertainty in connection with the
3 weighting of these factors.

4 Does this add an extra element of
5 uncertainty to the exercise?

6 A. Well, for the major radiosensitive
7 sites, so, the gonads -- no, I have to be careful
8 because there was a set of weighting factors that
9 applied in 1977 and with the new update on the
10 radiation risk data, 1990, some of the factors have
11 changed a bit.

12 But for the major sites which were
13 gonads, bone marrow, lung, breast, and then there are
14 some others of less sensitivity. I would say that
15 there's relatively less uncertainty.

16 These are numbers that are derived from
17 statistically significant excesses of lung cancer, for
18 example, in an irradiated population and they have some
19 uncertainty of course, but relatively less than for the
20 minor components.

21 Now, in this weighting system virtually
22 every organ of the body is given a weight, and a weight
23 is given even for organs which have not been shown to
24 be particularly radiosensitive, these are called
25 remainder organs and, just for completeness, they are

1 assigned a role in this weighting process. For those
2 there's a great deal of uncertainty, it tends to be in
3 the direction that we assign a weight to them when the
4 weight could well be zero.

5 Q. I see. Now, in paragraph 38 of the
6 UNSCEAR document, in addition to the uncertainty which
7 we have discussed arising from the weighting factor,
8 there are also a couple of health effects or health
9 consequences which appear to be excluded from the
10 effective dose equivalent.

11 For example, zero weight is given to
12 curable cancer.

13 A. Yes. That was true in 1977 but it's
14 not true in the 1990 publication, it is included.

15 Q. The second is the failure to account
16 for the difference between age distribution of workers
17 and that of the public at large and the failure to
18 include hereditary harm in generations beyond the
19 second are also deficient. Have they been remedied in
20 1991?

21 A. Well, the 1977 recommendations were
22 particularly directed at occupational exposures and
23 they really -- I mean, they did address some aspects of
24 public exposure, but that wasn't the main purpose, and
25 they didn't differentiate and it may well be that at

1 that time there wasn't enough evidence to really
2 distinguish.

3 In 1990 there is a risk figure of 4 times
4 10 to the minus 2 per sievert given for, I think it's
5 18 to 65 age distribution representing workers, and a
6 value of 5 times 10 to the minus 2 for the full
7 population age distribution. So there is a separate
8 number given in the newest recommendations.

9 Q. So one can say there is a range of
10 uncertainty in the weighting by the ICRP; secondly, the
11 concept of effective dose equivalent has some
12 limitations in it, so that this is not by any means a
13 comprehensive statement of all impacts on human health
14 generation from the nuclear fuel cycle?

15 A. Well, there's uncertainty in any
16 estimate that's derived and we have talked quite a lot
17 about others. You know, I don't think anyone who uses
18 these numbers should think that they are right to the
19 third decimal, they are the best estimates in the
20 opinion of the people who have studied these matters
21 based on the best evidence that is available in 1990,
22 and it's certainly possible that as more evidence
23 becomes available, they will change.

24 Q. Let me ask about another concept
25 which is built right into the very first part of this.

1 In the second paragraph on page 5.1 the index used for
2 expressing risk is fatalities per gigawatt year of
3 electricity produced.

4 And does that formula or that concept
5 fully capture the length of time over which humans will
6 be exposed to radiation from the nuclear fuel cycle and
7 I'm speaking also of the waste, the decommissioning
8 process, and so on?

9 A. Well, for each of those activities
10 you have just mentioned there were estimates given of
11 fatalities per gigawatt year and they were based, for
12 example on the case of radiological exposures, on
13 induction of fatal cancers, for example, any time
14 during the succeeding lifetime of the person who was
15 exposed. So they do take into account that time
16 course.

17 Q. But we know that the radiation can
18 persist in one form or another for many thousands of
19 years, in some cases. How are effects down that path,
20 over that time frame accounted for in that formula?

21 A. Well, it is true, it would be
22 different for an occupational exposure compared with
23 estimating the fatalities as a result of, say, mining
24 waste, and throughout this chapter there is, I think,
25 reference to where the sources of information for these

1 non-generation fatalities were obtained, documents such
2 as ACNS 10 I think was cited.

3 So what I think we have said is that we
4 have tried to provide Ontario Hydro's specific
5 information with respect to the risks of generation.
6 We have tried to add in, based on the literature,
7 values that pertain to the rest of the fuel cycle, but
8 we have only used literature values, we don't have
9 specific knowledge of our own in some of these areas,
10 most of these areas.

11 Q. Well, in your opinion, does the use
12 of the concept of fatalities per gigawatt year of
13 electricity produced, does that take into account the
14 full range of health effects.

15 A. Ah. Well, I think this is -- part of
16 the discussion we started to have about ICRP 77. The
17 reason fatalities are often cited is that they are
18 available for many different kinds of activities. It's
19 well understood when someone has died and has not died.

20 There are many other kinds of health
21 effects that may or may not be associated and they are
22 often more controversial, they are hardly ever
23 recorded, so in order to provide a sound basis, even if
24 it's not complete.

25 In 1977 for example, the ICRP focused on

1 mortality.

2 Now, as I say, in 1990 they felt that
3 it's possible with the incidence information that's
4 available to take into account other factors, but this
5 is in the area of radiological risk and most other risk
6 areas are not that well developed.

7 Q. So I guess my point is that the title
8 Impacts on Human Health should be qualified
9 substantially?

10 A. Well, no. But it certainly does take
11 into account, for example, genetic effects, that's
12 included and non-fatal cancer is included.

13 Q. In what form, under fatalities per
14 gigawatt year?

15 A. Well, I guess we have to talk about a
16 specific number, because outside the area of
17 occupational exposure, I guess, I'm not sure that in
18 every case they have taken into account all these
19 things.

20 These are relatively rough numbers in
21 some cases. I guess I should say that when the ICRP
22 ignored non-fatal cancers in '77 it was in the
23 knowledge that it was likely that there are about an
24 equal number of non-fatal cancers. So if you wanted
25 that impact as well you would double the number they

1 had.

2 And, similarly, if we are talking about
3 an estimate that hasn't taken those into account, you
4 could be wrong by a factor of 2. But that's probably
5 not the case. For example, the 5 times 10 to the minus
6 2 number is for fatal cancers, the ICRP recommends
7 another number which will take into account genetic
8 effects and non-fatal cancers.

9 Q. And you are speaking frankly only of
10 cancers, we are excluding non-cancer adverse health
11 implications?

12 A. Well, the ICRP and UNSCEAR believe
13 that the main cause, the main health detriment from
14 exposure to low dose radiation are these stochastic
15 effects I was talking about, cancers and genetic
16 effects.

17 Q. Let me then ask you to turn to page
18 5.2 of the chapter -- paragraph 5.1.2, Sources of
19 Uncertainties in Risk Estimates.

20 And I would also like you to refer to the
21 Exhibit 663 which is the U.S. EPA document entitled:
22 Risk Assessment Methodology and, in particular, chapter
23 7, Summary of Uncertainties in Doses and Risks.

24 A. What page was it in the EPA document?

25 Q. It should be Chapter 7-1, Summary of

1 Uncertainties in Doses and Risks.

2 Now, the point I wish to draw is that in
3 the EPA document, the EPA has given ranges showing
4 their best estimates of the range of uncertainty, for
5 example:

6 The uncertainty in the average
7 annual atmospheric dispersion factor...,
8 That's about the lower third of the page,
9 ...for any given location, can range
10 from a factor of 2 to 10 depending on
11 distance from the release point,
12 complexity..., and so on, and they
13 mention a number of other ranges.

14 Now, I notice in your Exhibit 507, the
15 sources of uncertainty, you haven't, as far as I can
16 understand, included ranges in these factors; is that
17 correct?

18 A. Yes, I think that's true. In 507
19 which is, as I said before, meant to be a summary I
20 guess, we haven't gone into it more than to identify
21 them such as on the page we were just looking at and
22 some comments such as the one to do with the dose rate
23 effectiveness factor in the appendix.

24 But in our annual summary and assessment
25 of environmental radiological data, we do include those

1 things.

2 Q. Well --

3 A. And those are much more detailed
4 documents of course.

5 Q. Among the uncertainties which the EPA
6 lists are, firstly, the annual atmospheric dispersion
7 factor and, secondly - the next bullet point - rate of
8 deposition of particulate to the given location can
9 vary by a factor of 10 - over the next page -
10 uncertainty in food chain transfer factors is large,
11 varies substantially from site to site, uncertainty in
12 dose conversion factors is small for external exposures
13 but variable for internal exposures - and the last
14 bullet point - uncertainty in risk conversion factors
15 which relate dose or exposures is estimated to a factor
16 of about three and so on.

17 There's quite a range; is there not?

18 A. Well, three is the number I think I
19 gave you. For example, with respect to the dispersion
20 factors, we do estimate that in our annual summaries
21 and we do this by comparing the emissions from the
22 stack and the dispersion factor is used to calculate
23 what the concentration would be at a certain site, then
24 we have environmental monitoring at that site and we
25 compare the predictions.

1 And we find that, in general, these are a
2 fairly extreme, in most cases we are much less
3 uncertain than a factor of 10, but the dispersion
4 factors, for example, that are used in the DEL
5 calculations include conservative assumptions and, in
6 most cases, they tend to overpredict the concentrations
7 we actually see.

8 Q. Turning to page 5.3 of Exhibit 507,
9 about the fourth or fifth bullet point down, the
10 studies use different assumptions regarding the number
11 of fatalities. In some studies a certain number of
12 working days lost may be equated to a fatality.

13 In a case such as that you wouldn't
14 necessarily pick up the effect on a retired person or
15 someone who's not working or a child; is that correct?

16 A. Well, you are talking here mainly
17 about the non-generation information that we have
18 included in the chapter and since we do just take
19 literature values, where there are other different
20 assumptions we have to accept that. Particularly with
21 respect to, for example, Ontario Hydro fatalities, our
22 mortality studies do include current workers as well as
23 people who have retired, and they are tracked.

24 Q. I see. Occupational hazards 5.3 at
25 the bottom of that page and then over the page there's

1 reference to silicosis. And that's a non --

2 A. Did you say 5.3?

3 Q. 5.3 of Exhibit 507.

4 Q. It's paragraph 5.2.1 page 5 -- I
5 guess it's page 5-3.

6 A. Oh, it's page 5-3 section 5.2.1?

7 Q. That's correct.

8 A. Okay.

9 Q. Sorry. We are speaking here of
10 silicosis.

11 A. Again, that's not really a hazard
12 that occurs commonly in Ontario Hydro operations. That
13 would be in the mining area.

14 Q. Mining.

15 A. Yes.

16 Q. Now, I take it you don't track the
17 health incidence for miners; is that correct?

18 A. We don't ourselves no, but there
19 certainly are studies in Ontario. The Ministry of
20 Labour has done a study of miners for a number of
21 years.

22 Q. I would like to then introduce the
23 Interrogatory 9.6.17 which I believe was given --

24 THE REGISTRAR: I didn't hear that.

25 MR. M. CAMPBELL: 146. It's 146.

1 You have it.

2 THE REGISTRAR: Can you give me that
3 number, please?

4 MR. M. CAMPBELL: I'm sorry. The
5 Interrogatory No. is 9.6.17, the number you gave it
6 this morning is 520.146.

7 DR. WHILLANS: Yes. I think this
8 response is what I intended to tell you. In addition
9 to the Ham Commission, I believe the Ontario Ministry
10 of Labour has published a number of reports describing
11 the mortality of miners.

12 These are not just uranium miners, of
13 course, but gold miners and other people that are
14 mining in Ontario.

15 MR. M. CAMPBELL: Q. Are the figures for
16 uranium miners, Elliot Lake, included in any way in
17 your calculation, fatalities per gigawatt?

18 [3:13 p.m.]

19 DR. WHILLANS: A. Yes, they would be
20 included. In the master table at the end of the
21 chapter there are a number of sub categories, one of
22 which is mining and there are radiological occupational
23 categories, and there numbers there which would include
24 this data.

25 Q. Very well, we will get to that in due

1 course.

2 I would like to speak a little bit about
3 or question you a little bit about the notion of
4 collective dose, at page 5-7, paragraph 5.3.4. And
5 just to assist as well, there is a definition at page
6 7-2 which I would like to ask you about.

7 A. I think you said page 5-7, you meant
8 5-10.

9 Q. I am sorry. If I said 5-7, I'm
10 sorry, I meant 5-10. I am at paragraph 5.3.4, the
11 paragraph dealing with collective dose.

12 A. Right.

13 Q. I also draw to your attention, page
14 7-2 of Exhibit 507 where collective effective dose is
15 defined.

16 So for a collective dose, collective
17 effective dose, you take the number of individuals in
18 the population times the individual effective dose
19 equivalent; is that correct?

20 A. It would be times the average or you
21 would just sum up all the individual doses, yes.

22 Q. So that to compute that, one of the
23 key factors is the number of people that you are
24 including in your formula?

25 A. Yes.

1 Q. And so, you take a size of
2 approximately 30 kilometres which is referred to here
3 at page 5-11 of Exhibit 507. Now you recall this
4 morning I mentioned to you the choice of UNSCEAR of a
5 radius of 100 kilometres, we spoke about that. Could
6 you tell me why UNSCEAR would choose 100 kilometres for
7 its purposes, whereas here 30 kilometres has been
8 chosen, how that is justified?

9 A. Well, if you read that section of
10 UNSCEAR, they are trying to provide an average for
11 world reactors, for example, of many different kinds,
12 located near cities, away from cities, and they have a
13 reference population which is some hypothetical area of
14 Europe, with a certain population density, and their
15 categories are, I believe, 100 kilometres for local
16 dose, 1,000 for regional and global is the rest.

17 For our purpose, we believe that the
18 local dose is, as it says on 5-11, the dose out it a
19 point at which the activity in the environment is
20 hardly distinguishable from background, it will depend
21 on the nuclide, and this is as it says, at which the
22 individual dose or exposure is 1 per cent of that at
23 the boundary. And given that the boundary dose is
24 something like 1 per cent of the dose limit, we are
25 talking about taking the doses out to something like 10

1 to the minus 4 of the dose limit, and that occurs
2 typically at about 30 kilometres. The value that's
3 used for water dispersion is a little bit different.

4 So we don't attempt to include
5 populations such as the rest of Toronto that would not
6 be significantly irradiated.

7 Q. How is the calculation made, by what
8 method?

9 A. Well, it does involve some
10 estimation. But we have vegetation sampling, TLDs for
11 environmental gamma and forth, spread around the
12 stations. I think there is a detailed description in
13 many of the summaries, for example, 520.15, that talks
14 about the way -- well, just for example. The average
15 annual airborne concentrations of tritium and Noble gas
16 are calculated for a number of points ij in the
17 vicinity of the station where ij is the midpoint of the
18 area IJ, and so forth.

19 So there a process of looking at the
20 population distribution around the station for each
21 segment estimating the dose given the environmental
22 measurements and then summing them by group.

23 So obviously there is some approximation,
24 but it's better than just taking a single measurement
25 and multiplying by the population within 30 kilometres.

1 Q. I presume that a large portion of the
2 emissions are windborne; is that correct?

3 A. The airborne emissions are, yes.

4 Q. Airborne. And the prevailing winds
5 are generally from west to east in that area; is that
6 correct?

7 A. Well, we have meteorological - I
8 guess Mr. Johansen should be talking about this - but
9 we have meteorological monitoring around the stations
10 and we mark it on a day by day basis. So it's not a
11 matter of saying that they are generally west to east.
12 We have wind distribution and that's factored into it
13 as well.

14 Q. But if you have a boundary which is
15 30 kilometres, you would then, in effect, average out
16 the effects of the prevailing wind, would you not, over
17 a large number of people? So, in other words, you
18 would have down wind a dose at a certain level, upwind
19 you would have a reduced dose, would you not?

20 A. Well, the 30 kilometres is where the
21 monitoring measurements show that the activity or the
22 dose approximates 1 per cent of the boundary dose, and
23 I think it's because -- we are talking about stations
24 generally located on lakes, so in addition to the
25 prevailing winds we have on and offshore breezes.

1 I don't think it's true that we have
2 predominantly one direction.

3 Maybe Mr. Johansen would want to talk
4 about that.

5 MR. JOHANSEN: A. Well, I could just
6 support what Dr. Whillans has said so far, that we do
7 monitor the dispersion meteorology parameters at the
8 sites and in the region surrounding the sites on an
9 hourly basis, and we have a detailed meteorological
10 dispersion, a data base, and that provides us with a
11 frequency distribution of any dispersion parameter that
12 is used in these calculations. We are, therefore, able
13 to come up with on an annual basis what the exposure
14 would be at any sector around the site in question.

15 Q. Another factor which appears in this
16 paragraph is the correction for background
17 contribution, what is the significance of that, please,
18 Dr. Whillans?

19 DR. WHILLANS: A. This is the top
20 paragraph on 5-11?

21 Q. That's correct, yes. About the tenth
22 line down.

23 A. Oh, sure. Okay. Well, we also have
24 it TLDs, for example, and environmental sampling well
25 removed from stations, hundreds of kilometres, and we

1 use these to estimate what the background level of
2 tritium in water, for example, might be. And when we
3 are estimating the contributions from the station, we
4 don't include background contributions.

5 Q. Well, this means that what you are
6 doing is that Ontario residents in fact receive a dose
7 from every other operating nuclear reactor, certainly
8 in the Great Lakes system, which is factored out for
9 your purposes; is that correct? Or not included in
10 your -- you, in other words, correct it.

11 A. But I think it is incorrect to think
12 that the doses far removed from the station are large.
13 For example, we did --

14 Q. I am not saying they are large; I am
15 just saying they are present.

16 A. Well, they are also very small.

17 When we did pre-operational measurements
18 around Darlington, some nuclides from Pickering were
19 detectable, some were not. Noble gases probably would
20 not be. Because dispersion even at that distance is
21 quite substantially.

22 Q. The correction factor which you
23 employ does have the effect of reducing the absolute
24 dose, which people are receiving, even though it may
25 be --

1 A. It certainly reduces the absolute
2 dose because what we are claiming is that these are the
3 doses due to the operation of a particular station.

4 Q. Fair enough.

5 The next sentence deals with the choice
6 of a 25 kilometre radius for water. And I wonder
7 whether there is a distinction between the 30 kilometre
8 or the 100 kilometre in that case.

9 A. Well, what it is, is you use the
10 population served by a water supply plant within 25
11 kilometres, so it is quite an irregular boundary in
12 this case. Because the population served by the
13 Scarborough plant, for example, with respect to
14 Pickering, is an area that goes well into Toronto.

15 Q. Well, why 25 as opposed to 30?

16 A. Well, again, I believe - this is not
17 particularly my area of knowledge - but I believe it's
18 with of the same general criterion that if we go to
19 plants that are beyond that, we are not going to be
20 able to measure activities in water that are different
21 from what it would be on a lake that had no plant, for
22 example.

23 Q. So you are saying it would meet at
24 least that 1 per cent?

25 A. Yes, I think so, yes.

1 Q. Fair enough.

2 MR. JOHANSEN: A. The rationale is
3 detailed in the annual radiological assessment report.

4 DR. WHILLANS: A. We have to remember,
5 for example, that most of the background in Lake
6 Ontario, for example, is not due to power plants; it's
7 due to atmospheric weapons testing and cosmic
8 generation, and so forth. So it would probably be
9 wrong or misleading to not take that out of a water
10 sample and assume that it was all attributable to a
11 station.

12 Q. Let me go on to the next paragraph
13 where you say it is possible to calculate for
14 long-lived and mobile radionuclides a regional and
15 global collective dose assessment and to integrate
16 those doses for future times.

17 You say the individual doses would be
18 calculated -- are highly uncertain and exceedingly
19 small.

20 My comment is, a small dose times the
21 billions of people, 2 billion people in the world, is
22 still a very large collective dose.

23 A. Well, we have spent quite a lot of
24 time exploring that, and we really have two situations.
25 There is the present world population, the global dose,

1 and then there is the question for a very long-lived
2 nuclide about calculating out to 10,000 years, say.

3 I think what is intended here, it is just
4 a summary, is that we measure Carbon-14 doses for
5 example. We are aware that there are global
6 implications for Carbon-14, and the average doses as I
7 indicated on that set of handouts I referred to this
8 morning, I don't have the exhibit number, but the
9 average dose to the global population is very, very
10 small. The collective dose is substantial. I agree,
11 and that's why we are not ignoring them.

12 Q. Could we move over to page 5-15, and
13 this is perhaps a small point. Just for my interest.
14 The very bottom line, possible removal of radionuclides
15 from tailings before -- has that ever been done
16 anywhere or is that a realistic option?

17 MR. JOHANSEN: A. It's an option that I
18 know has been considered by the mining companies but I
19 am not aware that that has been undertaken on any sort
20 of commercial scale. There may have been some pilot or
21 demonstration projects but I am not aware that that is
22 a commercially practised method.

23 Q. Okay.

24 A. Mr. Campbell, perhaps just while I
25 have got the microphone, I believe previously in

1 reference to Exhibit 519 and the charts, emissions and
2 so on, you were asking me about absolute values as well
3 as relative values. I believe I may have suggested
4 that those bar charts presented absolute emission
5 values; if I did, I apologize. What I should have said
6 is that the charts present absolute values for the
7 derived emission limits and the bar charts indicate the
8 relativity.

9 The source document which is the Annual
10 Radiological Assessments Report for 1990, Interrogatory
11 9.17.36, does present the more detailed emission value.
12 So I just wanted to make sure I didn't mislead you on
13 that.

14 Q. Thank you. I would like to go over
15 to page 5-18 of the exhibit, in particular, figure 5.3.
16 The heading is Ontario Hydro Nuclear Stations. Does
17 this include the tritium reduction facilities at
18 Darlington, and the incinerator at Bruce?

19 A. Yes, it does. And cool water farms,
20 and the aquaculture facility.

21 Q. So by nuclear stations you mean the
22 full range of facilities.

23 A. All of the Ontario Hydro nuclear
24 facilities.

25 Q. Does it include the Carbon-14 and

1 tritium, is that included in the estimation of the
2 dose.

3 DR. WHILLANS: A. The local doses yes.

4 Q. Is that included in the total
5 collective public dose?

6 A. Yes.

7 Q. At the bottom that page, page 5-18,
8 the DPSE, that means Darlington Probabilistic Safety
9 Evaluation, calculates an estimated mean risk of 6
10 times 10 to the minus 2 person sieverts per year to the
11 surrounding population out to a distance of 100
12 kilometres from the station from accidents effecting
13 fuel in the core.

14 I am interested in the lower and upper
15 bounds of that calculation. You have given us the
16 mean.

17 MR. KING: A. The full study, the full
18 DPSE study is an exhibit, and in the results chapter
19 they do have the information on the uncertainty factor.
20 I haven't got it available right now. It could take me
21 a couple of minutes to dig it out. It's in the results
22 chapter of the DPSE. Chapter 14 which is an exhibit.

23 Q. Why was the 100 kilometres chosen as
24 the area?

25 A. It's a similar reason to what Dr.

1 Whillans was referring to, with respect to normal
2 releases, this is an accident release, it's a distance
3 at which the dose would be small compared to the dose
4 nearby the plant. It is also a distance where using
5 the models, the atmospheric dispersion models that we
6 use, they just don't apply to long, very long
7 distances, because you have, as you go out from the
8 plant, wind shifts, you don't have a constant wind
9 direction, and the models really don't really apply
10 much beyond that 100 kilometre range.

11 From a collective dose basis, I believe
12 this would cover the majority of the dose. This
13 distance would cover most of the Toronto and most the
14 populous areas in Southern Ontario.

15 Q. Just taking your numbers of 1.1 times
16 10 to the minus 3 fatalities and multiplying that by,
17 say, 2.8, to a gigawatt per annum, according to our
18 calculations that gives us a 3.1 chance in 1,000 each
19 year for four years. Is that a fair calculation? Or
20 12 in 100, a chance of 12 in 100, 12 in 100 of there
21 being a fatality in that time. Is that a reasonable
22 estimate?

23 A. Well, it doesn't sound right. I
24 guess I will have to do some calculations. If I can
25 come back after the break, I can redo some calculations

1 for you, it might be quicker.

2 Q. Sure. Is the calculation which you
3 have made at the bottom of page 5-18, is this what
4 might be called a worse case scenario? What type of --

5 A. This 1.1 times, or the number which
6 is really in the DPSE is the 6 times 10 to the minus 2
7 figure, and that covers the scope of the study as is
8 described in the paragraph above and the paragraph we
9 are talking about. There has been an allowance later
10 on in that paragraph on page 5-19 for accidents that
11 are beyond the scope of the DPSE study. And since we
12 didn't have our own estimates, we went to a large
13 release from as reported in a recent U.S. nuclear
14 regulatory commission study, and that's the 2 times 10
15 to the 5th person sievert number, that's where that
16 come. So when you add them both together, it is our
17 best estimate of the total accident range.

18 Q. Including what you would consider the
19 worst case, the worst possible case?

20 [3:35 p.m.]

21 A. The worst accidents contribute to the
22 2 times 10 to the 5th figure and, as I indicated in
23 some earlier cross-examination, and as I think it
24 states right here, is that that number is, in my view,
25 certainly conservative because there are some

1 differences between U.S. reactor releases and our
2 reactor releases.

3 In particular, the percentage of caesium
4 137 in a light water reactor is much higher than in a
5 CANDU reactor because they don't have on-line fueling
6 and their fuel is in the core, on average, much longer
7 and caesium 137 contributes nominally 60 to 70 per cent
8 of the total long-term dose and we have three to five
9 times less caesium 137 in a CANDU reactor.

10 Q. I don't really intend to belabour
11 this, I gather you have been questioned on this area
12 extensively. I would like to turn to page 5-21, which
13 is your second paragraph up from the bottom, beginning
14 with the words:

15 Total public radiological risk index
16 from all these contributors assessed is
17 .04 fatalities per gigawattyear and over
18 half of this due to reactor operation and
19 the remaining portion due to
20 conservatively assessed transportation
21 component.

22 In absolute terms what does this work out
23 to, in terms of the total energy produced? Do you have
24 a number, assuming, I believe, 11 gigawatts?

25 DR. WHILLANS: A. Well, with all of our

1 system operating, say, about 14 gigawatts at, say, 75
2 or 80 per cent capacity as a round number we could say
3 10 gigawattyears per year.

4 Q. So what would that mean in your
5 absolute terms, one death every two years?

6 A. That would mean .4 fatalities per
7 year.

8 Q. Approximately one death every two
9 years, would that be --

10 A. From the whole cycle, yes.

11 MR. M. CAMPBELL: That's based on your
12 calculations. I would like to spend a little time on
13 paragraph 5.5, Mr. Chairman, and on the last two or
14 three pages of this chapter, and so I thought perhaps
15 it might be appropriate to break.

16 THE CHAIRMAN: We will break for 15
17 minutes.

18 THE REGISTRAR: Please come to order.
19 This hearing will recess for 15 minutes.

20 ---Recess at 3:38 p.m.

21 ---On resuming at 4:08 p.m.

22 THE REGISTRAR: This hearing is again in
23 session. Be seated, please.

24 THE CHAIRMAN: Mr. Campbell.

25 MR. M. CAMPBELL: Thank you, sir.

1 Q. Mr. King, you were going to make a
2 calculation and I ask you to put it into lay terms if
3 you can.

4 In absolute numbers, can you tell me how
5 many deaths might be expected over a 40-year period?

6 MR. KING: A. Just based on what we have
7 on page 5-18 and 5-19 of Exhibit 507, and if you look
8 at the risk number from the DPSE, that's 1.1 times 10
9 to the minus 3 fatalities per year, or fatalities per
10 gigawatt year, assume that we have a system of 10
11 gigawatts and in 40 years you just multiply that
12 through and you would expect .44 fatalities.

13 If you look at the total risk, that is
14 the DPSE plus the more severe accidents that we have
15 got on the top of page 5-19, then the number would be
16 about an order of magnitude higher, which would be 4.4.
17 So it's somewhere in that range.

18 Q. So my very quick and rough estimate
19 was quite higher than that, but I am perfectly content
20 to rely on your calculations.

21 I would like to turn to page 5-24 of
22 Exhibit 507, the second last paragraph and I spoke with
23 Dr. Whillans about this the other day and this is the
24 first sentence of that paragraph which says:

25 As stated above, the overall risk

1 reported in this report is .22 fatalities
2 per gigawattyear.

3 I would like to just ask you about that
4 conclusion, Dr. Whillans, if I may. And I wonder if I
5 could ask you about some of the components that go into
6 that.

7 DR. WHILLANS: A. If you are going to
8 ask about components, maybe it would be easier to refer
9 to table 5-1 on page 5-28 which has them broken out.

10 Q. Fair enough.

11 A. By the way, Mr. Campbell, I have a
12 correction for you. We were discussing whether the
13 risk numbers we used in this document included all the
14 effects other than fatal cancers.

15 And I see, in this table in fact, we
16 used, for example, for occupational fatalities 4 times
17 10 to the minus 2, which is the number adjust for fatal
18 cancers. If we include them all, it would be about 5
19 times 10 to the minus 2.

20 Q. Okay. Which table are you referring
21 to, table 5.1?

22 A. Well, it's 5.3 actually which gives a
23 lot of the assumptions that go into the table, and
24 that's where you can see how we have calculated how
25 many fatalities there are.

1 For example, if we look at generation on
2 page 5-31--

3 Q. Right.

4 A. --sub category operation, far
5 right-hand column, you can see there is a 2.0 sieverts
6 per year, this is multiplied times 4 times 10 to the
7 minus 2 fatalities per sievert, because this is an
8 occupational population. If we had included the full
9 ICRP risk we would have used five.

10 Q. I see.

11 A. So we have just used (b) fatal
12 cancers in these calculations.

13 Q. Just fatal cancers?

14 A. Just fatal cancers, yes. And if we
15 had included the other forms of detriment as it's given
16 in the appendix, it would have been actually 5.3--

17 Q. Okay.

18 A. --for occupational.

19 Q. Okay. So am I correct in taking from
20 that that where at page 5-28, the summary, the table
21 5.1, the summary of the fuel cycle phases of health
22 effects of nuclear fatality, that number doesn't
23 include non-fatal cancers?

24 A. That's right.

25 Q. Now, you recall earlier this morning

1 I asked you in connection with Exhibit 658, that is the
2 article from the Annals of the ICRP, I asked you about
3 the decision to divide the numbers presented at page 26
4 of Exhibit 658.

5 A. 658 you said, Upton's article?

6 Q. That's correct. Yes, table 20, we
7 spoke about it earlier this morning. Now, if we don't
8 divide it --

9 A. I'm sorry, which table?

10 Q. I'm sorry, table 20?

11 A. Table 20.

12 Q. Page 26 of Upton's article.

13 A. Yes.

14 Q. That's the one we were speaking about
15 this morning where we have the--

16 A. Yes.

17 Q. --the DREF or D-R-E-F of 2.0. Now,
18 there is, I gather, some debate about the propriety of
19 incorporating that?

20 A. Well, yes. Actually I started to
21 read you ICRP's position and we never actually got
22 through that.

23 But it's fair to say there's some debate.
24 The range which has been suggested for various cancers
25 is 2 to about 10, this is a number in UNSCEAR, in BEIR

1 and in NCRP reports.

2 The human data at low doses and dose
3 rates is relatively thin. There are a number of
4 studies, for example, medical exposures which give you
5 some indication. Some of those suggest there's not a
6 large factor, some of them suggest there is a factor,
7 and 2 is what ICRP has chosen for reasons that are
8 documented in their publication.

9 Q. Well, what I'm trying to get at is
10 the range, an acceptable range for the finding or the
11 overall risk finding of .22 fatalities per gigawatt per
12 annum and one of the matters excluded, of course, the
13 non-fatal cancers which, in effect, would not properly
14 be included in fatalities per gigawatt per year?

15 A. Right.

16 Q. But the dividing factor of 2 which
17 is -- as you say, some people put it in, some people
18 would not, is also an area which is also a component
19 which could have an effect on that number of .22
20 fatalities; would it not?

21 A. Yes, it would.

22 Q. Well, another number which could have
23 an effect, if you turn over the page to page 25 of that
24 exhibit, table 19, and I'm looking at the UNSCEAR and
25 the BEIR 5 estimates which were divided in two on the

1 next page.

2 If you look at the footnote (a)
3 respecting the UNSCEAR estimate, they say:

4 From table 14 based on age average
5 co-efficients..., and then in brackets
6 (the estimates would be roughly 50 per
7 cent higher if based on age specific
8 co-efficients as indicated in tables 9
9 and 10).

10 So is that another area where one could
11 get a greater result than that suggested by you?

12 A. Well, this table, as far as I can
13 see, has nothing to do with ICRP risk numbers, although
14 I agreed earlier they are similar.

15 Q. I know this has nothing to do with
16 ICRP, but it's another way of measuring this.

17 A. I'm not sure whether the problem of
18 age averaging or using specific numbers was addressed
19 in the same way by ICRP.

20 But, I mean, it's certainly true, there
21 is uncertainty and when you get down to individual age
22 groups the uncertainty grows because the number of
23 excess cancers in the study data is very small. So
24 there is uncertainty, yes.

25 Q. And if we look at Modan's article,

1 Exhibit 659, which we talked also about this morning,
2 his introductory remarks, page 59 and the very top of
3 page 60, he says that:

4 In some cases you get an excess
5 risk for Gy..., which I can ask you to
6 compare to the sieverts that we are talking about,
7 ...may differ by as much as two orders of
8 magnitude.

9 So there is a body of literature?

10 A. Well, the way I took this section in
11 fact, and this may be the basis of our small
12 disagreement about the tone of this article, was that
13 he says in the introduction that there are all these
14 references in the literature which have given various
15 estimates, and some may differ by two orders of
16 magnitude, but he doesn't say whether or not some of
17 these are scientifically credible estimates.

18 I think he's talking about the range of
19 numbers that are in the literature somewhere and then
20 he is going to go on and discuss potential sources of
21 error and so forth.

22 So, I mean, I don't think I could accept
23 that there are two orders of magnitude of uncertainty
24 in some of these estimates just because a single paper
25 seems to feel that that's the case.

1 Q. That's a fair answer. I'm just
2 pointing out that there is some discussion about that
3 type of issue.

4 A. By the way, for our purposes, Gy and
5 sievert can be used interchangeably.

6 Q. All right, thank you. In addition,
7 when you take a collective dose and limit it to a
8 relatively small area, for example 25 kilometres or 30
9 kilometres, that may also have an effect of reducing
10 the number of people within your so-called catchment
11 area, or within the area of people affected.

12 That's another way in which these
13 fatalities could be underestimated?

14 A. Well, again, I believe for Ontario
15 Hydro's population collective dose estimates, for
16 example, we have gone to an area for which the doses
17 due to tritium, Noble gases, all the major contributors
18 are almost completely captured.

19 It's true for some nuclides like
20 Carbon-14 or there may be additional regional or global
21 doses, and we have talked about those with previous
22 intervenors.

23 Q. Another factor which hasn't been
24 included which wouldn't necessarily address the issue
25 of fatalities is also neurological and behavioural

1 effects due to exposure of unborn children in the
2 uterus; is that correct, would that also be an effect?

3 A. Well, the appendix of our 507 talks
4 about that category of in utero exposure particularly.
5 That is a very, very specialized response to radiation
6 exposure.

7 It's been shown to occur only at high
8 dose, it's not clear at all that it occurs at very low
9 doses such as would be found in occupational
10 environment or certainly in the public environment, and
11 it occurs only in a very restricted 8 to 15 week
12 gestation period.

13 So it's not something that's going to be
14 a general effect.

15 Q. Well, taking into account the several
16 uncertainties that we have just touched on apart from
17 the non-fatal cancers and the birth defects and what
18 have you that I just mentioned, is it possible -- would
19 it be scientifically acceptable to come up with a
20 fatality -- a risk of 2.2 fatalities per gigawatt per
21 annum; in other words, an amount 10 times greater?

22 A. Well, I certainly wouldn't apply,
23 say, a factor of 10 to that number directly. I think,
24 since we are looking at the table, we should notice
25 that the .22 is mainly derived from occupational

1 exposure, 80 per cent of it .17, and of that 70 per
2 cent are the radiological totals and so forth, and I'm
3 going down to the fact that the generation radiological
4 normal is a major contributor.

5 Now, for that we are not talking about in
6 utero exposures, we are not talking about some of the
7 modelling uncertainties that have to do with population
8 doses, and we are talking about people who are
9 individually monitored for internal and external
10 radiation, we know their doses quite well, and there is
11 still the residual uncertainty of what the risk per
12 unit dose is, but most of these other things don't
13 apply in that particular part.

14 And we could go through other individual
15 groups, miners for example don't usually include
16 pregnant women. And, you know, there are reservations
17 that you have to apply before you could use a factor of
18 10 on all these numbers.

19 Q. What range would be acceptable to
20 you, could you give us an estimate? I asked you this
21 the other night and we were trying to prepare.

22 A. Yes. Well, you asked me actually
23 last night at six o'clock and I have thought about it.
24 I would think that as far as the occupational
25 exposures, radiological exposures go certainly a factor

1 of 3 at least, perhaps 3 or 4, that gives a factor of 3
2 for the risk estimation and some extra uncertainty in
3 dose monitoring and so forth.

4 When you start looking at some of the
5 other groups, I agree there may be quite a lot of
6 uncertainty in these numbers, primarily because we
7 haven't generated them, we have taken them from the
8 literature, and I really don't know, but generally
9 those are quite small.

10 If you look at the other substantial
11 contributors, for example, the public radiological
12 exposure, public accident exposure, I think we know
13 those reasonably well but they do have more uncertainty
14 because these are environmental exposures with
15 uncertainty in the environmental pathways.

16 On the other hand, we may well be
17 overestimating the risk per unit dose because these are
18 very low exposures. And I think we can't really put a
19 number on that.

20 Q. So you cannot give a range?

21 A. Well, certainly not at the level that
22 you would want to talk about an overall confidence of
23 95 per cent level, for example.

24 You know, I would think that the
25 radiological are all subject to the uncertainty in the

1 risk estimate which is a factor of say 3, and so I
2 certainly wouldn't argue about a factor of 3.

3 But some of the others, I just don't know
4 the information, these are literature values.

5 DR. CONNELL: And you would apply that 3
6 on the downside as well?

7 DR. WHILLANS: Yes, yes. It could be
8 zero at some of these low exposures.

9 MR. M. CAMPBELL: Q. I think that was
10 the point made by Modan effectively, he said we are
11 really not sure, it could go either way--

12 DR. WHILLANS: A. That's right.

13 Q. --at the end of his article. Such
14 data in either direction would hopefully shed more
15 light on the complexity of the issue.

16 A. I mentioned to Mr. Poch there is more
17 than just a fringe community that believes that very
18 low doses actually have positive health benefits,
19 and ICRP discusses that as well and says: Well, the
20 evidence is not strong enough to accept this as an
21 assumption.

22 But I think it's the case that the
23 uncertainty is in both directions, especially for the
24 environmental exposures.

25 Q. I would like to touch on one last

1 topic before we leave Exhibit 507. I think I can go to
2 Appendix 2 for that, if I may, and I would like you to
3 just keep in hand the exhibit we were looking at a
4 moment ago at page 26, it was Exhibit 659, the article
5 by Upton.

6 A. 658?

7 Q. I'm sorry.

8 THE CHAIRMAN: 658.

9 MR. M. CAMPBELL: I'm sorry, 658.

10 Q. Now, in appendix 2 at page AP 2-3
11 about the middle of that paragraph you refer to a dose
12 and dose rate effectiveness factor, DDREF and I want to
13 contrast that with the exhibit we were speaking of at
14 table 20 where we speak of a DREF.

15 Now, can you tell me the difference
16 between those two concepts?

17 DR. WHILLANS: A. Well, in general, I
18 think I can. The idea is that both low dose and low
19 dose rate independently perhaps show lower response to
20 radiation than high dose and high dose rate. In many
21 of the studies these things are hard to separate
22 because low doses are often given at low dose rates.
23 [4:25 p.m.]

24 But the point is that mechanistically,
25 there are reasons to suspect that either low dose or

1 dose rate might have a lower response because of repair
2 systems in cells.

3 And ICRP, for example, refers to a DDREF,
4 whereas some of the other documents just refer to a
5 DREF.

6 Q. So what is the meaning of your dose
7 and --

8 A. Dose and dose rate effectiveness
9 factor.

10 Q. What does that mean?

11 A. It means a factor which takes into
12 account either or dose and dose rate, either one or
13 both.

14 Q. Now, in comparison - it's getting
15 towards the end of the day - I wanted to ask you about
16 the numbers which appear in Preston's report, this is
17 Exhibit 661 which we also looked at earlier this
18 morning, and in particular at page 35 where a table is
19 set out. At the bottom of the page, 35, the reference
20 to linear estimate is the estimate that one gets by
21 extrapolating from high dose to low dose on a linear
22 basis; is that correct?

23 A. Well, I haven't read this page, so I
24 will take what you say.

25 Q. Read the page because I am a layman

1 approaching this.

2 A. These tables don't even seem to be
3 numbered, unless it's in the Japanese.

4 Q. I can't speak to the Japanese.
5 Everything else is Greek though, I can tell you.

6 A. I will accept that that's what it
7 means.

8 Q. Assume a linear extrapolation.

9 A. Yes.

10 Q. We were speaking this morning about
11 various ways in which the numbers can be extrapolated.

12 A. Yes.

13 Q. So this a linear extrapolation.

14 A. Yes.

15 Q. Now you notice in the column it says:

16 Range suggested by use of UNSCEAR
17 factors for low dose extrapolation.

18 Now, UNSCEAR has taken the linear
19 estimate and then basically reduced it.

20 A. Well, I don't recognize these
21 numbers. I guess I would note that this is a 1987
22 paper, so we are not talking about the 1988 UNSCEAR
23 estimates. I really would have to look through this
24 section.

25 Actually, when I saw that you had

1 provided this paper, I thought we were in for real
2 trouble, because the way in which the estimates have
3 been modified to do with dosimetry has to do with the
4 present assumption that there were essentially no
5 neutron exposures in the Japanese cities whereas
6 previously some of the effects had been attributed to
7 that.

8 One of the critical things in knowing
9 what correction to make is what RBE is, it says here on
10 the left-hand side to use for neutrons.

11 Q. What is RBE?

12 A. RBE is an acronym for relative
13 biological effectiveness. And it is known that
14 neutrons and alpha particles and other high linear
15 energy transfer particles are more effective.

16 Q. Let's just keep it at the 5.

17 A. That's the problem. I think that
18 there isn't good information, certainly not unanimity
19 about what the RBE should be. So they often present 5,
20 10 or 20, which is the normal range that's been
21 considered.

22 Q. Would the bulk of the neutrons come
23 at the 10 and 20 range?

24 A. No, it wouldn't be just like that.
25 It depends on the energy. ICRP gives values for

1 different energies, but I think the question is what
2 was the energy of the exposures that resulted in these
3 health effects.

4 And so, to my understanding, there is
5 still uncertainty about what to use and that's a part
6 of the uncertainty in the present dose estimates.

7 Q. I want to take that, just for a
8 moment, and go back again to the table, table 20, at
9 page 26 in Exhibit 658, where the DREF is referred to,
10 and here the UNSCEAR/BEIR numbers are stated to be
11 divided by two. My point is that it may be a double
12 division; in other words, a division by four, from the
13 linear estimate. If that is correct, would that change
14 any of your conclusions?

15 A. Well, I really think that can't be
16 true. For example, we can look at the BEIR report
17 directly, and the absolute cancer deaths per 10 to the
18 4th are given, there is a table that's given, and the
19 numbers come out to approximately twice the number
20 given here, it's about 1,000 per 10 to the 4th per
21 sievert. So I think this has been divided only by
22 factor of two.

23 And as I say, in the BEIR tables, they
24 have the actual numbers and they are in the order of
25 1,000 for this age distribution.

1 Q. So you would say that is not a
2 multiplication by two times two, a division of two
3 times two; it's a division by two alone.

4 A. I think so, yes.

5 Perhaps of the extra D in DDREF was
6 misleading. But that really is not indicating that
7 there is two factors that are applied independently.

8 It is just that the evidence about this
9 reduction factor often comes from a situation where
10 both the dose and dose rate were divided and they have
11 usually -- well, ICRP anyway, has called it a dose
12 and/or dose rate effectiveness factor.

13 Q. If your assumption or if your answer
14 is wrong and you are in error on this, I am not
15 suggesting any --

16 A. No.

17 Q. Is possible then that the error
18 factor could be in fact four times? We are looking at
19 a much more significant error?

20 A. Well, I am quite sure that is pretty
21 speculative.

22 Perhaps we can leave it that we will
23 inform you if we have any reason to think that's not
24 true. But I am quite sure in going through these we
25 will find that there is only a factor of two applied.

1 Q. Fair enough.

2 A. That's the same sort of number that's
3 in the ICRP document, and I am sure they just applied a
4 factor of two.

5 MR. M. CAMPBELL: I think, quite frankly,
6 Mr. Chairman, that concludes my questions on Exhibit
7 507. I have a number of questions on hydrogen sulphide
8 and standard setting, and one or two very brief
9 questions on the preparedness of hospitals in an
10 emergency. I don't know whether you would like me to
11 start that tomorrow. I think I can finish in about an
12 hour, an hour or so. I am in your hands on this.

13 THE CHAIRMAN: We have got another half
14 hour to go, so why don't we do another half hour and
15 stop.

16 MR. M. CAMPBELL: Okay, fair enough.

17 Q. Just to cover a few points then. The
18 issue of health costs. I take it you do not have any
19 numbers or figures or calculations which would show the
20 dollar costs of attempting to treat or to hospitalize a
21 cancer victim by ranges of various types of cancer. I
22 take it that's --

23 DR. WHILLANS: A. I think that was our
24 interrogatory response, that we don't have that
25 information.

1 Q. And that's not a part of your
2 analysis overall?

3 A. No.

4 Q. The issue of hydrogen sulphide, I
5 don't intend to spend a lot of time on this because I
6 believe Eugene Bourgeois will be dealing with this, but
7 one of the questions I would like to put has to do with
8 the burning off of hydrogen sulphide at the Bruce heavy
9 water plant.

10 I gather that there has been evidence
11 that a flare is used to burn off hydrogen sulphide on a
12 continuous basis; is that accurate? Am I correctly
13 informed?

14 MR. JOHANSEN: A. In my direct evidence
15 I indicated that a flare system with the addition of
16 propane to ensure combustion is used to convert H(2)S
17 to SO(2), yes.

18 Q. So you are releasing sulphates and
19 residual hydrogen sulphide as a result of that?

20 A. Yes.

21 Q. Do these sulphates produce sulphuric
22 acid or acid rain which is a respiratory irritant? Is
23 that one of the results this?

24 A. Well, certainly in the long range
25 regional situation, SO(2) is a precursor to sulphate or

1 acid deposition. And SO(2) is the primary air
2 pollutant, and certainly has the potential at certain
3 concentrations to cause health effects including
4 respiratory irritations.

5 Q. Would hydrogen sulphide be expected
6 to enhance the acid, acidity, the irritating effect of
7 the sulphates, would the combination of these produce a
8 greater --

9 A. Again, you are asking about a
10 synergistic effect--

11 Q. That's correct, yes.

12 A. --of the two together.

13 I am not aware that there is an adverse
14 synergistic effect the two together. The emission
15 levels as indicated by our monitoring records over the
16 years indicates that the atmospheric H(2)S levels are
17 pretty low and are normally well below levels that
18 would cause health effects.

19 Q. I am going to put a question --

20 A. That is true for SO(2) as well, I
21 might add.

22 Q. I would like to put to you the
23 interrogatories which were entered earlier, 144, 148,
24 and 147. I won't necessarily take them in that order.

25 In 147, this is Interrogatory 9.17.2, the

1 last paragraph defines an emergency, it says:

2 An emergency is declared when a
3 concentration of 50 parts per million or
4 more of hydrogen sulphide is detected in
5 the atmosphere at or beyond the boundary
6 of the plant, or the person in charge
7 considers the situation is not in
8 control... And so on.

9 I would like you to compare that
10 concentration with the interrogatory .148, where
11 Ministry of the Environment standards require maximum
12 ground level concentration of hydrogen sulphide not
13 average more than 20 parts per billion for any
14 30-minute period. I asked you, I believe, this morning
15 to comment on, if you would be prepared to comment on
16 the emergency situation as opposed to the standards set
17 by the Ministry of the Environment. Why is there such
18 a difference?

19 A. Well, I will ask Mr. King to add his
20 comment on the emergency plan, which is what you are in
21 effect referring to here.

22 Q. No, I really wish to focus on the
23 concentration. That is my concern.

24 A. Yes, I will first respond to that
25 part of the question.

1 You are right, the Ministry's air quality criterion
2 for H(2)S is 20 parts per billion or .02 parts per
3 billion, to put it on the same footing as the figure in
4 question, and that's for ambient air quality averaged
5 over a one-hour period. And they also have a criterion
6 for points of impingement such as ground level
7 concentration, and it is the same number, .02 parts per
8 million, but averaged over only a half hour. And
9 that's really the one that we try to meet, that's the
10 most restrictive criterion obviously. And that is for
11 long-term or chronic exposure control.

12 The 50 parts per million is the warning
13 level, or action level, in the event of an emergency.
14 And I might add further that, as I indicated in my
15 direct evidence, that still is below the level of
16 significant irreversible health effects.

17 Q. But is it below the Ministry of the
18 Environment standard?

19 A. No, it obviously isn't. But the
20 Ministry standard is for normal operations.

21 Q. I see. Let me then ask you, I would
22 like to refer to Interrogatory 9.14.23, it was produced
23 this morning as .144, and there lists a number of
24 releases. Do you have any information on whether or
25 not, in connection with any of these releases, the

1 release was in excess of the Ministry of the
2 Environment standard or in excess of the 50 parts per
3 million which is your emergency threshold? Do you have
4 any information on that?

5 A. Well, I recall monitoring information
6 for incidents of exceedance over the last five years, or
7 at least the five-year period from 1985 through '90,
8 and I have been advised that it is no different for
9 1991. And in those five, now six years of operation
10 there was never more than one exceedance of the half
11 hour ground level concentration, or ground level
12 criterion, and the exceedance was quite small in each
13 case, well, well below the 50 part per million.

14 We are talking about the neighborhood - I
15 could check it and give you precise figures - but if
16 memory serves, in some of the years there were no
17 exceedances, but in those years where there was one
18 exceedance, the exceedance was -- the actual measured
19 level was in the neighborhood of mid 20s to perhaps 30,
20 something like that, parts per billion.

21 Q. And when you were measuring what form
22 of measurement were you using, in NPC measurement or
23 the DEL measurement?

24 A. We are talking about concentration
25 measurements.

1 Q. Concentration, okay.

2 I have a couple of questions on emergency
3 measures, I think for, Mr. King. The Hare report, I
4 believe it's Exhibit 660, I photocopied just the
5 content, table of contents of Mr. Prince's Review of
6 Nuclear Emergency Measures Affecting Ontario, and Other
7 Related Matters. This appears as appendix 6 in Roman
8 numerals to the technical appendix to the report.

9 There can be various types of
10 emergencies, you may have transportation accidents, you
11 may have spills of uranium ore, or concentrates. You
12 get an accident at a nuclear reactor where there may be
13 a minor or major release of radioactivity beyond the
14 plant's containment structure. I think we could refer
15 to perhaps four, one at Chalk River in the early 50s,
16 one at Windscale in the U.K. in '57, Three Mile Island
17 in '79, and Chernobyl. And my question is, if we take
18 those four scenarios and apply them to, say,
19 Darlington, do you have any assessment of the strain or
20 the burden which would be faced by local hospitals and
21 local emergency services? Would these be part of the
22 emergency plans which Hydro contributes to? Do you
23 have any information on the burden which might be
24 placed on the health care system?

25 MR. KING: A. I can talk about what we

1 have in our plans and how the hospitals are prepared
2 for the various occurrences that are allowed for in our
3 plans, but I think your question was much beyond that.

4 If we had these four events occurring at
5 Darlington, and really I don't accept that we could
6 have these --

7 Q. Let me ask you a much simpler
8 question. Are hospitals and emergency services such as
9 ambulances and so on included in your plans?

10 A: Yes, they are.

11 Q. And is that coordinated through the
12 Ministry of the Solicitor General, with the Ministry of
13 Health and so on?

14 A. It's both the Ministry of the
15 Solicitor General and the Ministry of Health are
16 involved in various aspects of that, and I can go into
17 quite a bit of detail, if you wish.

18 [4:45 p.m.]

19 Q. Well, I'm just concerned about the
20 potential costs of that disruption in the event of some
21 form of releases which might be contemplated at
22 Darlington.

23 A. You are interested in the costs?

24 Q. The costs. Do you have any
25 information on the costs of emergency preparedness in

1 the hospital health care sector?

2 A. No. I'm afraid I have got
3 information on what is done - and, in fact, many of the
4 costs are borne by Ontario Hydro - in the training and
5 providing of equipment to the various hospitals which
6 are designated hospitals around all the plants.

7 But I'm afraid I don't have those dollar
8 values available.

9 Q. Okay. I don't know that an awful lot
10 turns on it.

11 MR. M. CAMPBELL: I would like to spend
12 some time on standards setting. I don't know whether
13 in 10 minutes I can really -- I have cleaned up the two
14 or three smaller matters, but I do have two or three
15 others.

16 THE CHAIRMAN: I take it you would like
17 to stop now and get ready to do standards tomorrow?

18 MR. M. CAMPBELL: As subtle as I can,
19 sir.

20 THE CHAIRMAN: All right. We will stop
21 then until tomorrow morning at ten o'clock.

22 MR. M. CAMPBELL: I expect to be about an
23 hour at the most.

24 THE CHAIRMAN: All right.

25 MR. M. CAMPBELL: Thank you.

1 THE REGISTRAR: We will adjourn until ten
2 o'clock tomorrow morning.

3 ---Whereupon the hearing was adjourned at 4:50 p.m., to
4 be reconvened on Wednesday, May 6, 1992, at 10:00
5 a.m.
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